OUTCOME ANALYSIS FOR CLOSED INTRAARTICULAR DISPLACED CALCANEAL FRACTURES WITH LOCKING PLATE

Dissertation submitted to

THE TAMILNADU DR.M.G.R MEDICAL UNIVERSITY

In partial fulfilment of the regulations for

The award of the degree of

ORTHOPAEDICS

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I**, Dr.E.SIVA** solemnly declare that this dissertation **"OUTCOME ANALYSIS FOR CLOSED INTRAARTICULAR DISPLACED CALCANEAL FRACTURES WITH LOCKING PLATE"** is a bonafide work done by me at Government Thanjavur Medical College And Hospital between 2013–2016,under the guidance and supervision of **Prof.Dr.S.Kumaravel**, M.S.Ortho., D.Ortho.,Ph.D., Department of Orthopaedic Surgery.

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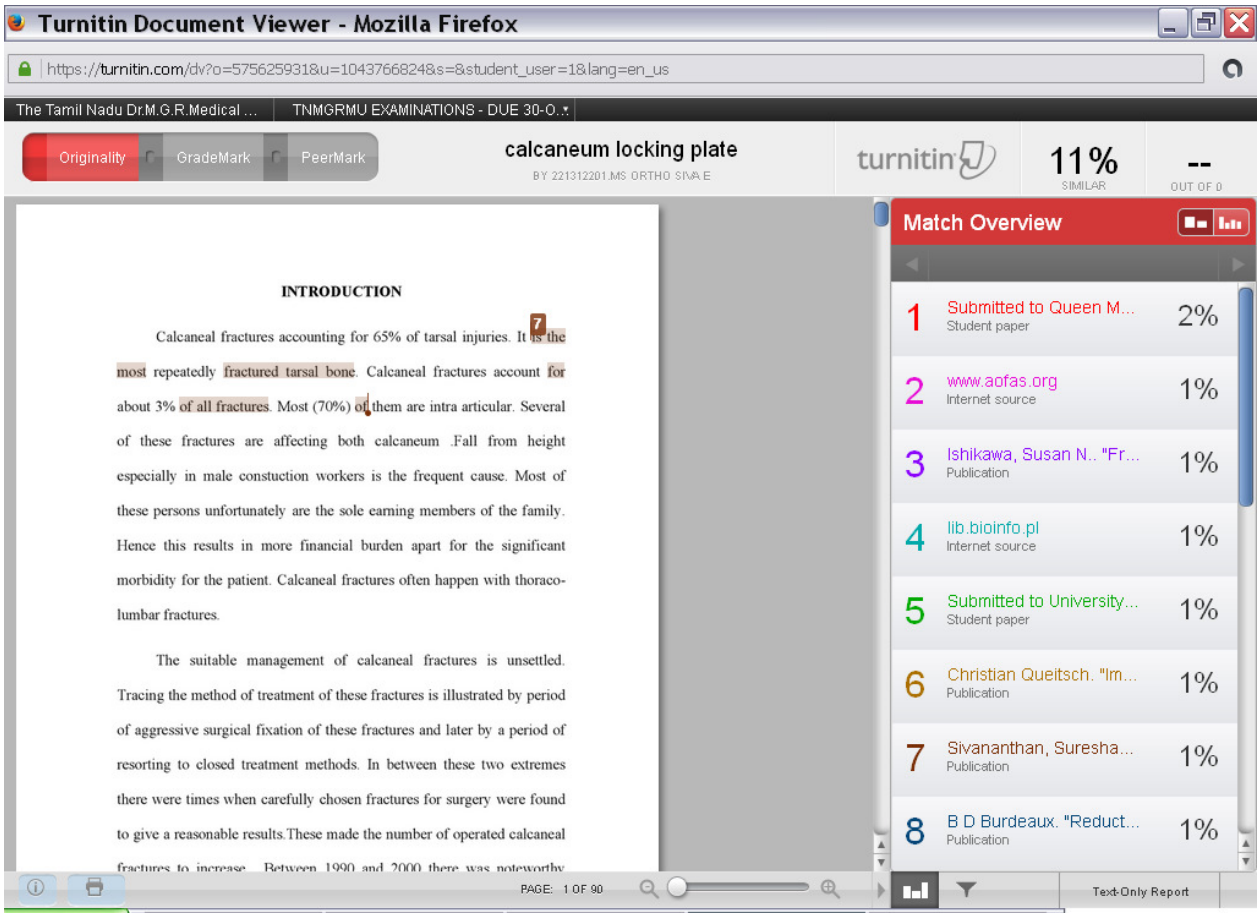
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INTRODUCTION
Calcaneal fractures accounting for 65% of tarsal injuries. It is the most repeatedly fractured tarsal bone. Calcaneal fractures account for about 3% of all fractures. Most (70%) of them are intra articular. Several of these fractures are affecting both calcaneum .Fall from height especially in male constuction workers is the frequent cause. Most of these persons unfortunately are the sole earning members of the family. Hence this results in more financial burden apart for the significant morbidity for the patient. Calcaneal fractures often happen with thoraco-lumbar fractures.
The suitable management of calcaneal fractures is unsettled. Tracing the method of treatment of these fractures is illustrated by period of aggressive surgical fixation of these fractures and later by a period of resorting to closed treatment methods. In between these two extremes there were times when carefully chosen fractures for surgery were found to give a reasonable results.These made the number of operated calcaneal
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INTRODUCTION

Calcaneal fractures accounting for 65% of tarsal injuries. It is the most repeatedly fractured tarsal bone. Calcaneal fractures account for about 3% of all fractures. Most (70%) of them are intra articular. Several of these fractures are affecting both calcaneum .Fall from height especially in male constuction workers is the frequent cause. Most of these persons unfortunately are the sole earning members of the family. Hence this results in more financial burden apart for the significant morbidity for the patient. Calcaneal fractures often happen with thoraco-lumbar fractures.

The suitable management of calcaneal fractures is unsettled. Tracing the method of treatment of these fractures is illustrated by period of aggressive surgical fixation of these fractures and later by a period of resorting to closed treatment methods. In between these two extremes there were times when carefully chosen fractures for surgery were found to give a reasonable results.These made the number of operated calcaneal fractures to increase. Between 1990 and 2000 there was noteworthy development in the management of calcaneal fractures an exemplified by the gross decrease in complication rates connected with the existing intervention of these potentially disturbing injuries.

SURGICAL ANATOMY

Calcaneum as a bone forms a base or vertical support for body weight. It is the biggest of all tarsal bones with many articulations. It also has many ligament and tendon attachments. It also functions as a lever arm powered by gastro-soleus. It also supports and conserves the length of lateral column of the foot.

Calcaneum has a thin cortical shell which encloses a mass of cancellous bone that remodels with various stresses applied to it. So it has been described being 'Egg like' i.e. hard on the outside and soft on the inside.

The anatomy of the calcaneum on its lateral aspect is particularly vital as mainly this lateral surface area is exposed during the most common surgical approach used for fracture fixation. Tuberosity is the most posterior aspect of the calcaneum; distal to the tuberosity, is the body of calcaneum.

In the plantar aspect of calcaneum, a small process in the slightly lateral portion is called the lateral process of tuberosity gives origin to muscles and attachment to plantar fascia.

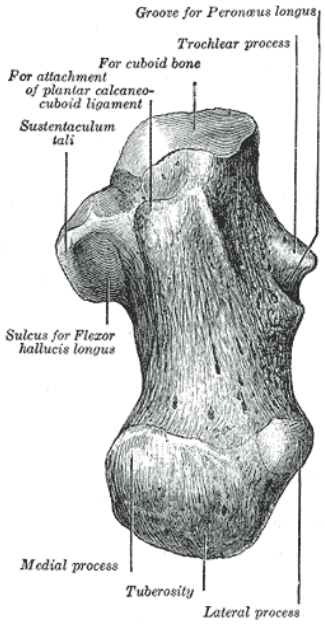


Fig. 1 Axial view

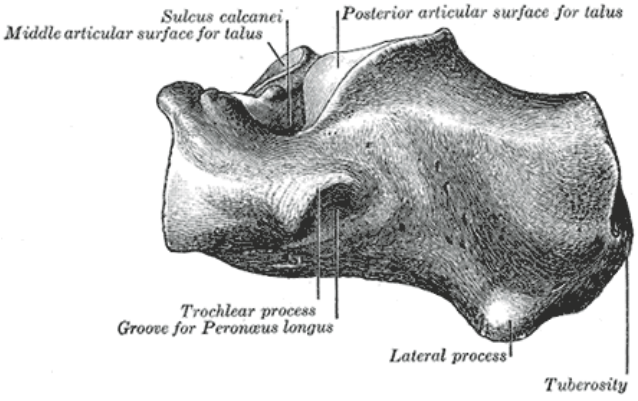


Fig. 2 Lateral view

Peroneus longus tendon pass in the lateral aspect of in the groove just under the peroneal trochlea (tubercle).

The lateral margin of posterior facet is observable in the middle part of the calcaneum on the lateral side. This is important in open reduction and internal fixation of intra articular fractures of calcaneum as the more lateral portion of the posterior facet usually has to be reconstructed and fixed with screws.

Distally on the lateral side, the articular surface of the calcaneocuboid joint is found.

The superior surface of the calcaneum has the three articular facets in the anterior half.

The largest facet is the posterior facet and is convex.

The middle facet which is slightly concave is situated on the sustentaculum tali. This facet frequently continues anteriorly as the anterior facet, also slightly concave.

The inter-osseous sulcus (calcaneal groove) lies between the middle and posterior facets. It opens broadly laterally and forms with the talar sulcus, the sinus tarsi.

These anterior middle and posterior calcaneal facets articulate with anterior middle and posterior talar facets to form the complex subtalar joint.

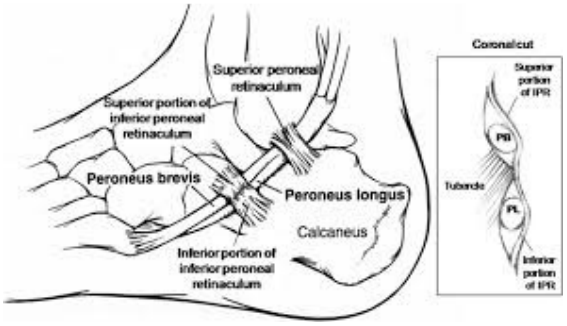


Fig. 3 Lateral view showing peroneus tendon

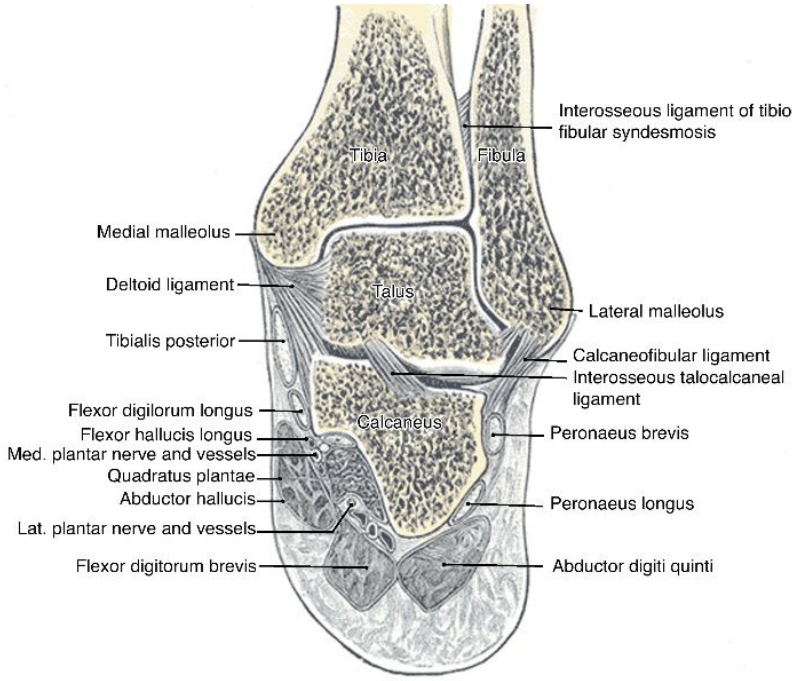


Fig. 4 Coronal section

The diagram given above (Figure 4) is a posterior or coronal view of the calcaneum, showing the anatomy of calcaneum at the level of the sustentaculum tali just in the anterior portion of the posterior facet.

Of special significance here are the sustentaculum tali and the middle and anterior articular surfaces of the distal lateral wall of the calcaneus.

The lateral view shows 2 angles on X-ray. **Bohler's Angle** (Tuber joint angle; Fig 5) is the complement of an angle produced by two lines. The first line is drawn between the highest point of anterior process connecting to the highest part of the posterior facet or articular surface. A similar line is drawn between the same points on the posterior facet connecting to the most superior point of the tuberosity of the calcaneum. It usually measures between 25-40°. Loss of this angle on plain lateral radiographs means there is loss of calcaneal height.

Crucial angle of Gissane is an additional angle "formed by the downward portion of the posterior facet where it joins the upward portion. This angle faces the lateral process of the talus and is disturbed at the time of calcaneal fracture by axial compressive forces. The normal measure of the **angle of Gissane** is about 120-145°. Shown in Figure 6.

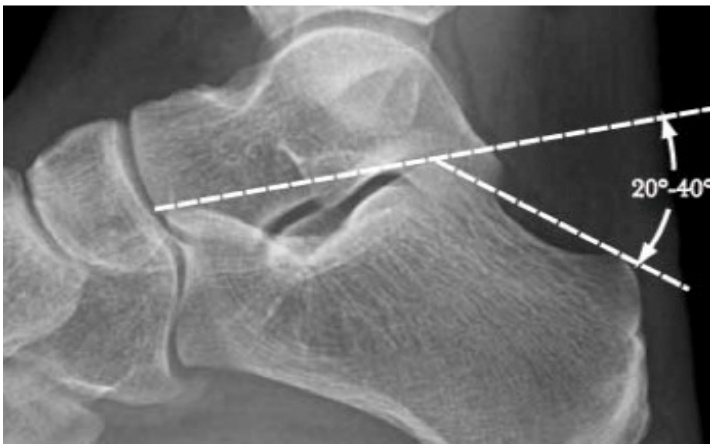


Fig. 5 Radiological Lateral view showing Bohler's Angle

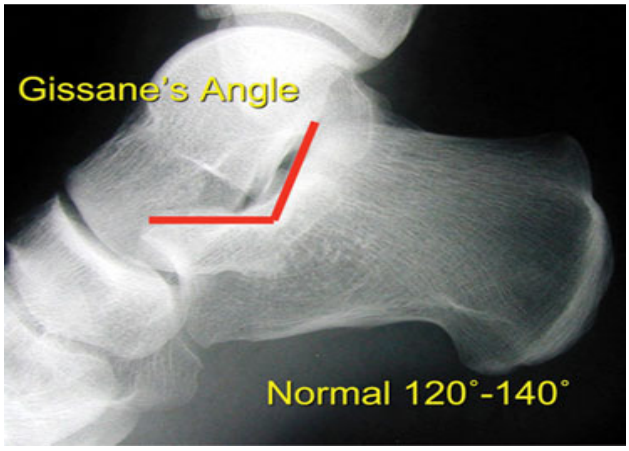


Fig. 6 Radiological Lateral view showing Gissane's Angle

An extra proximal coronal view of the calcaneus showing the posterior facet is an important view (CT cut). This demonstrate the quantity of comminution and displacement of the posterior facet with intra articular fracture of calcaneum.

There are few unique anatomical aspects of calcaneum.

1. To permit passage of the tendons and neurovascular structures into the foot, the calcaneum is concaved out on the medial side

2. Thus the centre of calcaneal tuberosity to be a little lateral to the center of talus.

3. If a force is applied vertically to the talus, with the calcaneal tuberosity fixed to the ground, then shear stress take place all the way through the body of the calcaneum.

The calcaneum essentially breaks along this stress line, forming two main fracture fragments,(Figure 7)

1. medially -the sustentacular fragment and
2. laterally- the tuberosity fragment

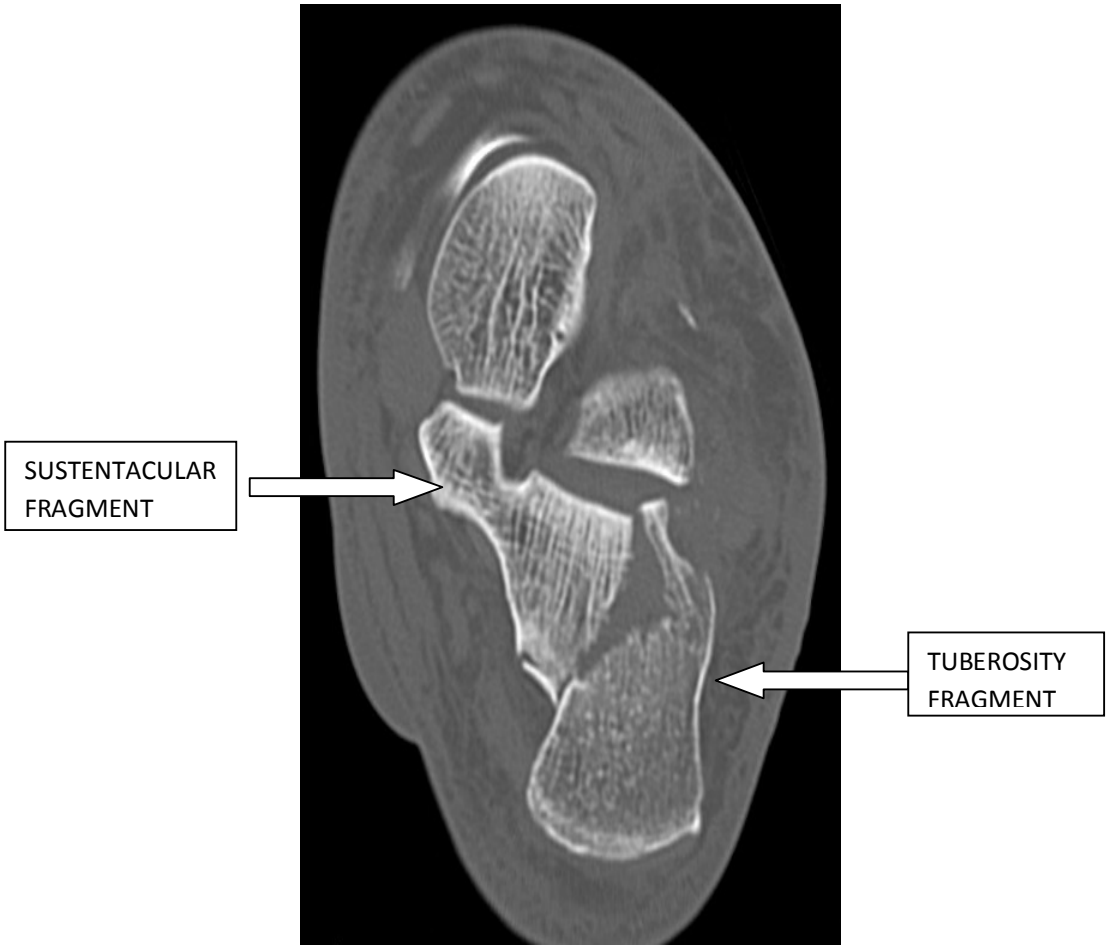


Fig. 7 Radiological Axial view

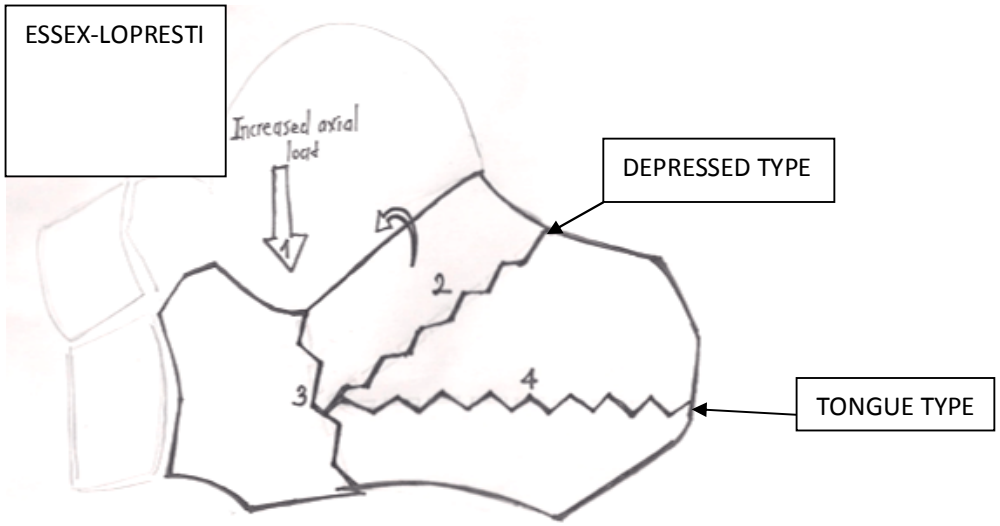


Fig. 8 Types of Essex-Lopresti

Transmission of this downward energy of the talus occurs, with the calcaneal tuberosity fixed on the ground. Thus the talus and the sustentacular fragment move inferomedially, and so calcaneal tuberosity is becomes more lateral and elevated. The talus powers its way and pushes the lateral part of the posterior facet into the cancellous bone of the tuberosity fragment.

Viewed from above, the talus and sustentacular fragment shift inferiorly and posteriorly. This leaves the tuberosity fragment in a lateral and anterior position. The anterior aspect of the tuberosity fragment rotates laterally, and the lateral tuberosity cortex is comminuted.

Based on the length of the supero-lateral fragments with a small part of the articular surface of the posterior facet, makes the difference between the types.

The two main regular types of calcaneal fractures are

(1) Joint depression type. Here the fragment is short; it extends only for a short distance behind the posterior facet.

(2) Tongue type. Here the fragment is long, and it extends to the posterior aspect of the calcaneal tuberosity.

These fracture lines are according to Essex-Lopresti. The fracture lines cross the postero-lateral part of the posterior facet in each.

The main means of fracture reduction in medial incision is the sustentacular spike. One must be aware of this. In this sustentacular fragment, there is a spike which is a thin, sharp structure on the medial side, consisting of mainly the medial cortex. This is very thin posteriorly and distally but almost immediately becomes turns thicker in the upper part.

This spike helps in identifying the sustentacular fragment. On table only after identifying this fragment, the other fracture fragments can be matched and aligned with it. This will restore the near original structure of the calcaneus. The reason for the primary fracture line (Essex Lopresetti) is driving down of the sharp taloid spur into the calcaneum especially in the everted position of sub-talar joint. In the inverted position of sub-talar joint, the tuberosity comes more directly below the talus; this causes a reduction in the shear stress.

Anatomy of calcaneum the mechanism of fracture

Mechanism and cause of the injury

A fall from height is the main reason of an intra articular fracture of calcaneum, typically this fracture occurs when a middle aged man (30-50) falls from a height of 8 feet or even high, but these fractures can

happen with falls from lesser heights, like in a domestic setting like a fall from a chair, particularly in the elderly citizen with osteoporotic bones. Rarely landing on the heel in motor vehicle accidents, floor board or brake pedal injuries also can cause intra articular calcaneal fractures.

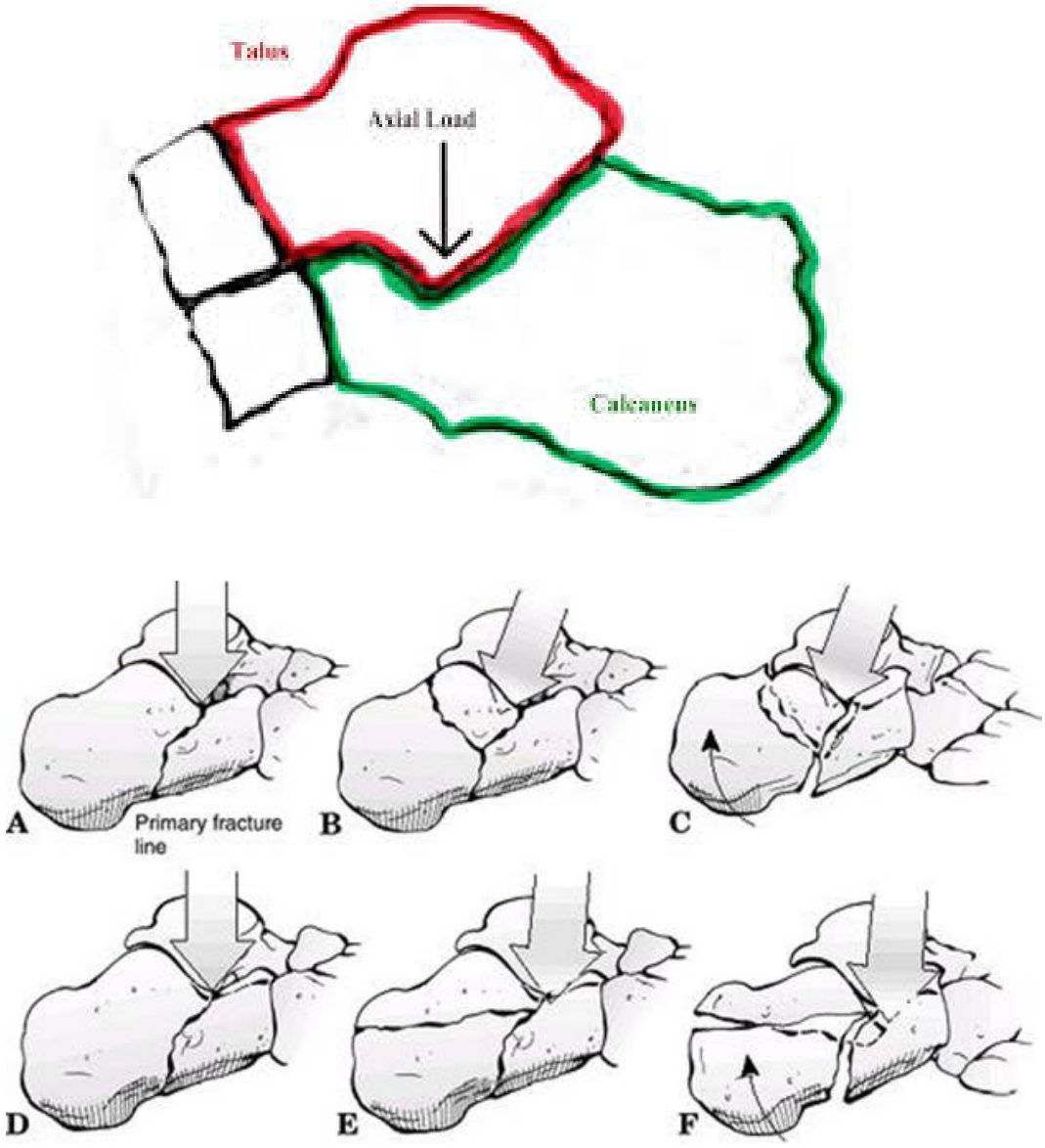


Fig 9,10 Mechanism of Fracture

REVIEW OF LITERATURE

Obviously originally in of calcaneal fractures, the treatment depended on the diagnostic modalities that were available at that period of time. Because of total absence of diagnostic tools from time immortal to the nineteenth century, naturally the only treatment approach is only careful neglect (ie conservative management) . This is because the special views and advanced CT scan of the calcaneum are needed to make the decision regarding reduction of intraarticular aspect of the calcaneum.

Cotton and Wilson recommended (1908) that one should not do an open reduction of a calcaneal fracture at all. The famous quote by McLaughlin compared open reduction and fixation of a calcaneal fracture to “nailing of a custard pie to the wall”.

Later in 1931 Bohler supported open reduction but still the main reasons for the dominance of non operative treatment were due to the the practical problems not only connected specifically with operative treatment of calcaneum but also to other general problems like ineffective anesthesia, deficiency of good quality intraoperative radiography like fluoroscopy and the type of antibiotics at that period. Also the poor understanding of the principles of internal fixation leads to more complications.

Conn in 1935 found poor results with the standard treatment methods, recommended primary triple arthrodesis, in a delayed manner. In this method he achieved exceptional results.

Later in 1943 Gallie, supported sub-talar arthrodesis as ultimate treatment but only after union of the fracture.

Discontented with either conservative or late surgical management of the calcaneal fractures, Palmer tried operative treatment of acute displaced intra articular calcaneal fractures using a standard lateral Kocher's approach. He reconstructed the joint by elevating the fracture fragment with bone graft and published his work in 1948. Later 1952, Essex Lopresti reported similar findings.

Not all surgeons were contented with the results of open reduction and fixation, Dick and Harris began started using Gallie's technique of subtalar arthrodesis for malunited fractures of calcaneum as the treatment of choice, even for acute calcaneal fractures. They showed excellent results with patients returning to work early. Following this many surgeons performed sub-talar arthrodesis for acute calcaneal fracture.

Even after all these in a long term follow up Lindsay and Daver, concluded that sub-talar arthrodesis was not only unnecessarly but also resulted in problems. They concluded that best results were got only with

conservative treatment of patients. As a result the operative treatment of acute calcaneal fractures once again went into disrepute. So only later, between 1960s and70s most workers advocacted of conservative management.

In the last 20 years, because of improved anesthesia, introduction of antibiotics principles of internal fixation and preoperative imaging CT and intra operative imaging intensifier have permitted surgeons to employ operative fixation for many intraarticular fracture, obtaining good results.

If the personality of fracture is not carefully studied and mode of fixation are not carefully selected and the basic principles of open reduction and internal fixation adhered to by the surgeon then results cannot be expected. Even if these newer techniques promise good results in displaced intra articular calcaneal fractures, experience with these for most intra articular fractures that treatment remains challenging.

Maintenance of Bohler's angle is necessary for satisfactory results along with maintenance of articular congruence of posterior facet of calcaneum and crucial angle of Gissane. Open reduction and internal fixation with locking compressive plate in displaced intraarticular fracture calcaneum shows good outcome. Results are more favourable in less comminuted as compared to more comminuted.[23]

Controversies also exit with regards to primary bone grafting to prevent collapse. A series of cases have been reported with no significant collapse, even without using bone graft for calcaneal fixation, showing no specific benefit with use of the bone graft to prevent collapse[20-22]

However, Leung et al[21], Thordarson et al[22], and Schildhauer et al[23] recommended use of bone graft or cement to increase stability and compressive strength of fixation and rapid rehabilitation. Zhongguo et all[22] study reports bone graft in the surgical treatment of calcaneal fractures carries no advantage.

EVOLUTION OF IMPLANT USE AND RATIONALE FOR LCP

The management of fractures of calcaneus has undergone a sea of change from the initial use of supervised neglect to the use of complicated closed reduction devices .Today there are complex implants , used for internal fixation needs better understanding of complex fracture anatomy and the maneuvers required to reduce the various fracture fragments. They also needs good knowledge about trauma mechanisms, better delineation of vascular zones and their relationship to skin incision, better stability with newer implants and bolder surgical interventions, whether by open or percutaneous means.

The consensus of the issue of the best implant for a particular type of calcaneal fracture is not arrived. Also there is no definite proof about the ideal modality of fixation. This is again due to availability of numerous implants, different methods of reduction, and many surgical approaches to the fractured calcaneum.

A clear and targeted understanding of the goals aimed at after calcaneal fracture fixation is vital and a prerequisite for implant use. The ideal achievement in any intraaricular fracture are better anatomical articular reconstruction, maintenance of the articular surface,

reconstitution of Bohler's and Gissane angle, less invasived faster surgery , minimal wound complications and early mobilization of the ankle.

Modified surgical techniques (appropriate use of the extensile lateral approach) and minimally invasive techniques when indicated, and better fixation devices for stability.

A clear and better understanding of the hindfoot biomechanics has also helps to fix the extra articular fractures and the tongue type of fractures with modifications of the technique described by Essex loperesti, Gissane, and the other authors.

Despite the contrary evidence favouring both modalities, today there is a gradual shift in the management of calcaneal fractures from conservative to surgical treatment. This is due to better understanding and clarity of patterns of fractures by radiological techniques like Computerised tomography .There is still confusion in the aspects of open reduction an internal fixation, and many difficulties persists.

One main reason for failure of surgical intervention is inappropriate implant or incision choice. Complications manifest in the form of inadequate fixation and inadequate 3 dimensionl reconstruction and wound related complications.

Implant decision is a complex issue .This is because the complex anatomy of the calcaneum, an odd shape of the bone which breaks like an egg and it is difficult to maintain various articular surfaces and tuberosities in position till healing process is completed. Its odd shape is the reason behind difficulty in application of implants. Regaining the Bohler's and Gissane angle and reconstruction of posterior facet are all the complex task. It is always accompanied with some soft tissue compromise

Last three decades, new calcaneal implants have evolved due to better knowledge on biomechanics, metallurgy and implant designs. Newer implants allow early mobilization. Use of these implants depends on surgeons expertise, patient expectations and cost issues, also there should be consideration to the local factors like skin conditions or wounds, swelling, blister etc

IMPLANTS

SCREW FIXATION OF CALCANEAL FRACTURE

Avulsion Extaarticular fractures are comparatively easily stabilized and fixed with 1 or 2 lag screws can be applied percutaneosly with minimal surgical trauma.

WIRE FIXATION OF CALCANEAL FRACTURE

For complex calcaneal fractures K wires are inadequate. While in undisplaced avulsion fractures or undisplaced body fractures, if carefully applied Kwires give percutaneous stabilization, though early mobilisation cannot be achieved. K wires are ideal for temporory stabilisation. But now these are supplemented with external fixation as a support to maintain the fracture reduction of different fragments.

EXTERNAL FIXATORS OF CALCANEAL FRACTURE

These are handy in open fracture, in calcaneal fractures also , they can be used as a temporary devices till the open wound heals or to maintain the fracture geometry till the fracture healing, in addition to K wires. In comminuted fractures which appear as a bag of bone the ideal management is by image guided percutaneous multiple K wires fixation and supported with these external fixators.

PLATES AND SCREW FIXATION OF CALCANEAL FRACTURE

Implants for depressed intraarticular fractures have always created controversy and confusion but there is aggreement developing regarding that the depressed facet should be elevated and the tuberosity should be maintained, the posterior depressed facet and anterior process should be aligned.

As already told the evolution and modifications of implants have made the calcaneal implant more complex, and the user is often confused by the complex looking plates. The implants are costly due to patents, better technology. Locking plate principles has been applied to this area also.

Initially in the 1980s, the main goal of fixation was the facetal reconstruction which is achieved by 2 screws in compression mode and this is followed by offloading by a single neutralization plate on the lateral surface. It also maintained the configuration of the tuberosity and the anterior process in relation to the reconstructed facet, bone grafting is needed indeed. This gave the surgeons fairly good results when employed by surgeons with experience; however weight bearing needed to be postponed.

In this method, there was poor maintenance of elevated posterior facet and late collapse of the fracture reconstruct happened. There were also plate related lateral complications. Thus the implant development progressed further.

In the 1990s there is an emergence of double plate configurations, and the development of single construct H or Y reconstruction plates. (e.g) Bezes used a 2nd short straight plate in addition to a flat plate, forming a "Y" construct. Letournel used the principles used in acetabular and pelvic fracture surgery, modifying them to develop the concept of a single "Y" plate and the anatomic reconstruction plates (with arms) which were made particularly for calcaneus.

LOCKING PLATES OF CALCANEAL FRACTURE

With the turn of 21st century the emphasis and importance shifted to low profile but versatile implants. These type of implants allowed stable fixation .The plate profile/thickness was reduced which in turn allowed us to minimize soft tissue breakdown. The plates were also made less rigid for moulding to irregular surfaces of calcaneum, and their complex structure allowed varied non parallel screw placement to ensure rigid support of the bone fragments at various levels. This lead to the development of thinner, single construct calcaneal locking plates. These have better results in comminuted fractures also. With the emergence of

locking plate concept by Wagner and AO group, the concept was extended for use in foot and ankle. Synthesis Medical GmBH, Solothurn Switzerland marketed a versatile locking calcaneal plate with 15 locking holes.

CLASSIFICATIONS

There is a broad agreement that the degree of joint destruction at the time of injury decides the results of the calcaneal fracture management. Radiological information has limitations like the position of the limb during the radiography, lack of adherence or standardization of the radiographic procedure .There is no handy classification system. Thus the assessment of every calcaneal fracture and comparison of fracture patterns becomes difficult.

Classification of intra articular fractures of calcaneum

1. Classification based on plain radiographs - Essex Lopresti /Rowe et al/ Souer & Remy/Stephenson/Paley & Hall
2. Classification based on CT Scan - Crosby Fitzgibbons /Sanders/De Souza
3. Classification based on CT and plain X-ray - Orthopaedic Trauma Association

Malgaigne first described two different types of calcaneum fractures as intra articular and extra articular. Later Bohler launched his classification system based on the prognostic value of the fracture pattern differentiation.

In 1952 Essex Lopresti, introduced his simple but extensively used classification. However a major problem in this classification is the joint depression type comprises too many fracture patterns. This does not permit useful correlation between the fracture classification and the ultimate clinical result.

It was Crosby and Fitzgibbons who pioneered a CT based classification of calcaneum fractures by the fracture pattern of the posterior facet, dividing the intra articular fracture of calcaneum in to three types.

Later based on Souer and Remy's work which divided the posterior facet into 3 different columns, Sanders developed a classification where the calcaneum fracture was subdivided based on location of the primary and secondary fracture lines.

Eastwood et al. — classified fractures of calcaneum based on destruction of three main fragments. Carr divided the calcaneum into medial and lateral columns and considered the destruction of posterior

facet and calcaneo-cuboid joint. Levin and Nunley considered soft tissue problems and found six groups.

Zwipp classified calcaneum into 5 main fragments and 3 joints. This considered the number of destroyed fragment and joints and the degree of soft tissue damage.

As already elaborated, for clinical use, Essex Lopresetti classification appear simplest but it is inadequate and cannot offer a outline for forming surgical strategies or for calculating the long term result. Sanders's classification is simple, comprehensive and has the advantage of allowing prognostication of results for various fracture types of calcaneum. Yet another classification called Zwipp classification, describe the typically complex pattern of calcaneum fractures.

The common classification followed is Sanders, which is based on the CT coronal image of the posterior facet which is more descriptive and complex.

SANDER'S CLASSIFICATION	
Type 1	All nondisplaced articular fractures (less than 2mm)
Type 11	Two-part fractures of the posterior facet
Type 11A,11B,11C	Based on location of primary fracture line
Type 111	Three-part fractures usually featuring a centrally depressed fragment
Types 111AB,111AC,111BC	Based on location of primary fracture line
Type 1V	Four part articular fracture

Fig.11 Coronal view

Type—1 Intra articular fracture which can have as many as three fractures lines and four fragments but they are only minimally displaced or undisplaced.

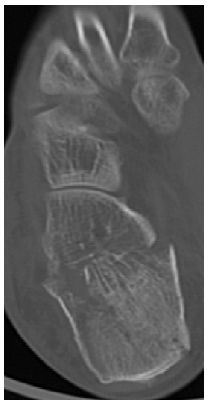


Fig.12 Coronal view – Type 1

Type—2 have two intra articular fragments and are divided into A, B, C subtypes depending upon the location of the fracture line.

Fig.13 Coronal view -Type 2

A - Being Lateral

B - Being Central

C - Being Medial

Type—3 have three fragments and two fracture lines

Fig.14 Coronal view – Type 3

Type -4 a minimum of four fragments with three fracture lines with significant displacement.

Fig.15 Coronal view – Type 4

Radiographic lines and assessment.

1. Lateral radiological view of foot is ordered for finding the involvement of sub-talar joint and disruption of Bohler's angle.

2. Harris view or Calcaneal axial view is ordered for assessing amount of widening of hind foot, loss of height, and some information about intra articular degree of fracture.
3. Antero Posterior view of hind foot is ordered for information about extension of fracture into calcaneo-cuboid joint.
4. Broden's view is ordered to delineate posterior facet. Here the foot is internally rotated to 30-40, xray beam is centered on the lateral malleoli, fired with cranially angled xray tube-position shifted serially from 40,30,20,10. As shown in figure.
5. CT Scan

   All patients who are possible candidates for surgical intervention must undergo CT scan study preceding surgery.

It is done with patient lying supine in the scanner with knee flexed and the foot as plantigrade as patient will allow. Both feet imaged simultaneously. Both coronal and axial images are taken. Sagittal computer reconstructions are also helpful.

MRI provides further status of soft tissue injuries.

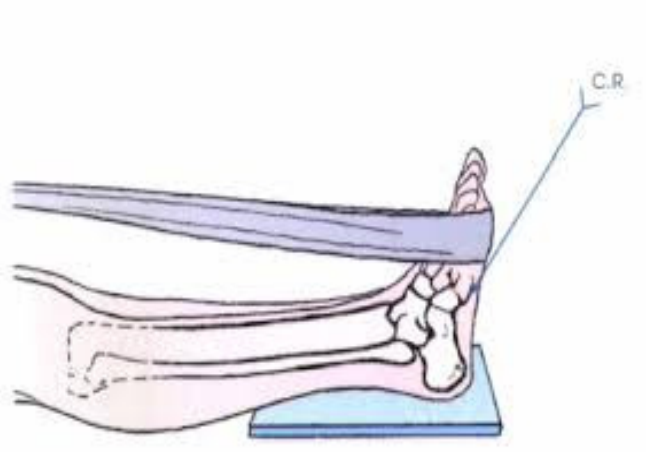


Fig.16(i) Axial view

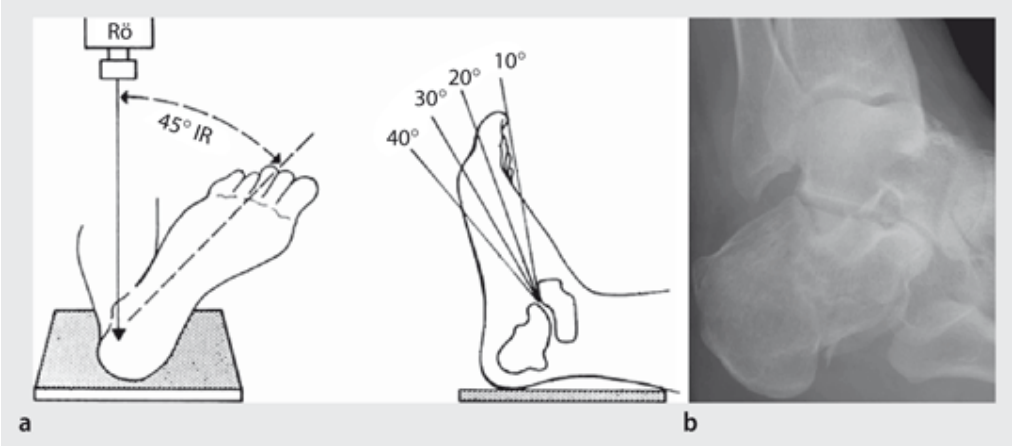


Fig.16 (ii) Broden's view

TREATMENT

The choice of treatment is as follows

1. Closed treatment

a) Accept position, no reduction and early motion.

b) Closed reduction, short term immobilization, reasonably early motion

2. Semi Open technique

a) Essex Lopresti close reduction by manipulation of the fragment with percutaneous pin and fixation.

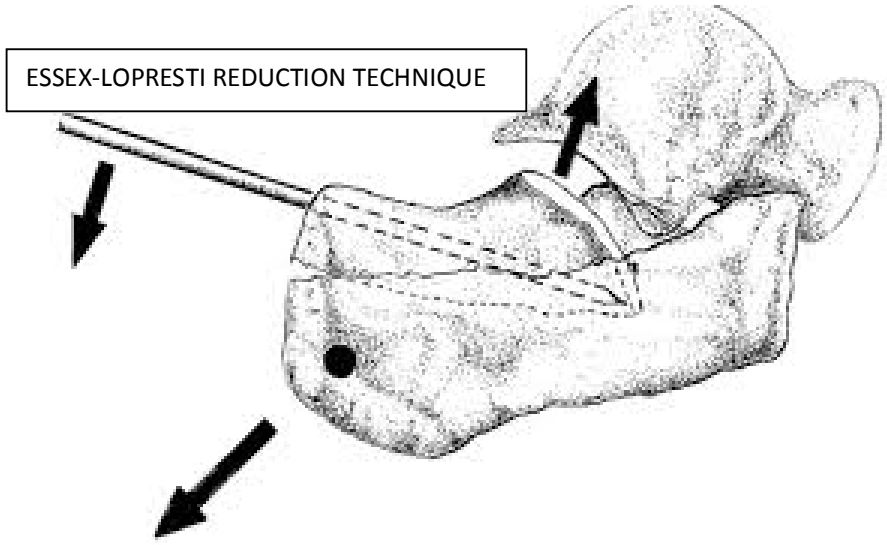


Fig.17 Essex-Lopresti Reduction Technique

b) Percutaneous techniques which are recently popular.

c) Limited open reduction and external fixation technique.

3. Open Surgical Technique

a) Open reduction and internal fixation with a lateral extensile incision.

b) Open reduction and internal fixation with a medial approach.

c) Combined medial and lateral exposure using open reduction and internal fixation.

d) Primary arthrodesis.

Closed treatment

It consists of "RICE" Rest, Ice application, Compression, Elevation of limb and NSAIDS. It is accomplished in two ways.

a) One has to accept the fracture as it presented to the surgeon without making an attempt to reduce, with short term immobilization, non weight bearing for 6-8 weeks followed by gradual early motion.

b) By external pressure fracture is manipulated manually or with tongs for reduction and immobilization done, later early physiotherapy for range of motion exercises are advised. Weight bearing is allowed after 8 weeks. Manipulating the fracture can be done by Omoto technique.

Semi Open Techniques are easy for the surgeon with low surgical risk to the patient than open techniques. But correct patient selection (i.e) only tongue type fracture patterns and determination on anatomic reduction of the joint surfaces can be expected to cause acceptable and good results.

a) Essex Loprestti and King's technique.

b) Surgical technique of Tornetta,

Open surgical technique. The indications

a) Type II and III Sanders with displacement more than two millimeters in the setting of soft tissue conditions that have no increased risk of complications and a patient — who can comply with post operative care and advise.

b) Type IV Sanders usually treated by primary subtalar fusion.

They are classified into following

a) Lateral approach

(i) Benirschke and Sangeorzan

ii) Sanders

The approach was described by Benirschke and Sangeorzan and popularized by Sanders. The advantage of this approach is that the reduction and fixation of the posterior facet can be done directly.

Limited approaches are

Palmer approach, Sinus tarsi approach, Small lateral approach, Extensile sinus tarsi approach, Geel and Flemister approach.

b) Medial Approach

i) McReynolds

ii) Burdeaux

This is based on the principle of restoring the medial wall of the calcaneal which can be done adequately only from the medial side. An accurate reduction produces stability, restores length and height and partially restores a width. The joint or tongue type fragment is reduced to restore the articular surface of the posterior facet.

c) Combined Medial and Lateral Approach

(i) Stephenson

ii) Johnson and Gebhardt

Stephenson pioneered a combined medial and lateral approach with rigid internal fixation with screws and staples, followed by early range of motion post operatively. Good results, with the good quality of fixation are achieved but there is limited visualization of the subtalar joint in this approach.

d) Early Primary subtalar fusion for those patients with severely comminuted intra articular fracture is advocated e.g. Sander's advised primary arthrodesis in his type IV fractures.

The order of importance is:

a) Reduction and fixation of the posterior facet (reconstruction of the posterior facet platform).

b) Correction for loss of height and increased width.

c) Reduction and fixation of fracture of the calcaneo-cuboid and anterior and middle facet joints.

COMPLICATIONS OF INTRA ARTICULAR CALCANEAL FRACTURE

It can be divided into

1) **Immediate complications**

   Fracture blisters, swelling, and Compartment syndrome

2) **Late Complications**

   Malunion, Arthritis, calcaneo —fibular abutment, heel pad problems

3) **Complications with non operative treatment**

   Arthritis with stiffness and pain

4) **Complications with operative treatment complications**

   Infection, Wound dehiscence, iatrogenic nerve injury

Fracture blisters and swelling

Acute calcaneal fracture accompanies significant soft tissue swelling. Fracture blisters may occur anywhere over the foot usually within 24-48 hours after injury and have clear fluid or blood. If there are extensive blisters then surgery is contra indicated. If incision is done through these blisters then wound infection is possible, so initial swelling

must be reduced by elevation. By pinching the skin of the heel a wrinkle must appear this is called the “wrinkle” test. It should be done before any surgical treatment.

2) An another common complication of surgical treatment is wound infection. It may be (i) superficial (in 10-27% of all cases) (ii) Deep (1.3-2.5% of all cases). Safety measures in calcaneal surgery Timing of surgery, methods to decrease swelling and meticulous surgical technique especially the lateral approach with sharp dissection to raise full thickness flaps from skin to periosteum, use of no-retraction technique by K wires, using Allgower stitch (atraumatic skin closure technique), and suture removal after 3 weeks are recommended. Post operative wound dehiscence usually begins at angle of incision and has been called ‘apical’ wound necroses. Flap edge necrosis can happen when the incision extends to the edges or watershed areas or the lateral heel, which is an area that receives blood supply from posterior peroneal artery. Superficial or deep wound dehiscence can happen as late as four weeks postoperatively. The risk factors are single layered closure, high BMI, lag of time between injury and surgery, smoking, diabetes mellitus.

Compartment syndrome.

This is caused by bleeding from cancellous bone fragments crushing high energy injury coupled with anatomic soft tissue constraint by the plantar aponeurosis. The calcaneal compartment, continuous with the deep posterior compartment of the leg has been described to be the compartment at risk after calcaneal fractures, incidence is 10%.

There is persistent pain, which is out of proportion to injury with severe swelling. There may be toe flexor weakness and stretch pain on passive extension of toes.

Fig.18 showing blisters over the ankle

There may also be associated plantar hyperesthesia apart from fracture blisters and plantar ecchymosis e present. Most reliable physical finding is tense swelling of the foot. Compartment pressure should be measured over calcaneal, medial, lateral, superficial and interosseus compartment of involved foot.

If the compartment pressure reaches 30 mmHg (or) with is under 10-**80** mmHg of diastolic blood pressure, then it is the time to do a faciotomy.

NERVE INJURY

Acute neurologic injury most commonly occurs. e.g iatrogenically in the lateral approach, Sural nerve involved and in the medial approach - calcaneal branch of posterior tibial nerve is involved. Injury to both medial and lateral plantar nerve can happen when screws or wires are inserted from the lateral approach especially anteroinferior aspect of the posterior facet.

Nerve Entrapment also can happen later due to soft tissue scarring or bony malunion or exostosis formation causing the impingement. This is usually from conservative treatment. The medial plantar, lateral plantar and calcaneal branch of tibial nerve medially may be involved and cause pain. Sometimes the sural nerve laterally also may be involved. When examined, Tinel's sign may elicit over the area of the involved nerve. This pain around the distribution of the nerve, may be apparent both at rest and while standing. Selective nerve blocks with anesthetics also may help to diagnose nerve involvement.

IMPINGEMENT OF TENDON AND BONE

Tendon impingement and calcaneofibular impingement can occur by

a) Fracture spikes protruding through the tendons.

b) Dislocation of the tendons from their anatomic groves

c) Entrapment of tendons between fracture fragments

d) Impingement of tendons between malunited bony fragments.

Peroneal tendinitis can be caused by implant irritation when a lateral approach is used.

Pain over the lateral aspect of the heel is the most common site of persistent pain after calcaneal fracture. This should be differentiated from secondary pain due to

a) Pure peroneal tendinitis

b) Calcaneofibular abutment and

c) Subtalar arthritis or

d) Combination of the above three.

Buckling or giving way when walking also may suggest peroneal tendon dysfunction ‘ To distinguish between pure peroneal tendinitis and calcaneofibular abutment ,confirm localization of pain along the course of the peroneal tendon and eliciting pain with passive dorsiflexion and resistance to evertion of the hind-foot.

Diagnostic peroneal synoviogram by injecting radiographic dye or local anesthetic or both to demonstrate stenosis or narrowing along the involved tendon sheath and induce pain relief.

Heel pad pain and heel exostosis

Heel pad pain is the second most common site of pain after a calcaneal fracture. It is due to injury to the heel pad close to calcaneum during the time of injury. Diagnosis is done by the presence of significant heel pain, over to the area of soft tissue and heel pad under the bone, tenderness on the side to side palpation or thumping over the heel pad. There will be thinning and increased mobility of the heelpad. Thus the heel pad will be softer and less firm compared to the uninjured site. Bony calcaneal spurs, heel exostosis develop from the undersurface of calcaneum in patients with injury to the plantar cortex of calcaneum after injury. It is due to proliferative bony changes at the origin of the plantar fascia.

Malunion occur commonly in conservative treatment but may occur in inadequately or improperly done reduction in surgeries. It results in

a) Widened heel syndrome

b) Pain and instability secondary to tendon impingement

c) Post traumatic arthritis of subtalar or calcaneocuboid joint

d) Hind-foot malalignment and altered gait secondary

e) Nerve impingement.

Pain can be due to varus malunion on lateral aspect of foot valgus malunion on lateral sub-talar area.

When examined there may be a) Callosities and sores over lateral aspect of foot b) Widened heel c) Abnormal shoe wear

Arthritis may affect - subtalar or calcaneocuboid joint .Subtalar incongruity or penetration of implants into the sub-talar joint may cause late arthritis. There is significant unloading of the posterior facet with as little as 2 mm of articular surface depression, supporting the concept of articular surface reduction as aim of treatment in operative treatment of calcaneal fracture.

Even in an anatomically reduced fracture, arthritis can occur due to cartilage injury that is caused by initial trauma. Thus it is also the severity of initial injury that determines the ultimate outcome and not the accuracy of articular surface reduction as obtained in one study.

Placement of implants within the articular surface may occur after operative treatment and implant exit is a must before weight bearing or range of movements. If left the patient might develop pain on weight bearing, aggravated by valgus or varus stressing of subtalar joint but with no significant tenderness on the lateral aspect of the heel.

AIMS

1. To analysis the radiological and functional outcome of closed displaced intraarticular fractures

2. To determine whether it is beneficial in maintaining restoration of Bohler's and Gissane angles, calcaneal height and anatomical articular reconstruction.

3. To determine the correlation exists between the timing of surgery and the occurrence of complications.

MATERIALS AND METHODS

This study was conducted in Government Thanjavur Medical College Hospital from 2013 to 2015. Patients with displaced intra articular fractures of calcaneum were selected and treated with open reduction and internal fixation with locking compression plate. Most (number) of these cases resulted from fall from height. Few (number) had history of Road Traffic Accident. The cases presented with swelling and pain of the heel and inability to walk.

All the patients were evaluated with X-ray of the calcnaeum — axial, lateral and AP views along with CT scan.

The patients for whom open reduction and internal fixation was planned were treated by limb elevation, ice application and crepe bandage to reduce the edema.

Injection tetanus toxoid was given to all patients. Except for a few (number) due to gross edema most of the patients were operated within 10-14 days of injury. All the patients were given pre operative antibiotics. In this study, we followed the Sander's classification to classify the fractures.

The calcaneal locking plate with 15 locking holes allows for fixation of different fracture pattern, with mouldable superior and inferior arms which provide support for anterior processes and plantar fragments. Angled and ascending hole supports the sustentaculum and provides a better support to the calcaneotalar articular surface. The plate is designed to be applied by a lateral extensile approach, and the moulding is done with the help of a special sleeve benders; multiple locking screws or standard small fragment screws provide unicortical and/or bicortical fixation. The threaded locking holes provide a fixed angle construct to support the articular surfaces of the calcaneus and permit multiple point of fixation to buttress small fragments .The locking hole provides 5 degree angulation when using 3.5 mm cortex screws and 15 degree angulation when using 2.7 mm cortex screws .This locking calcaneal plate is side specific, made of titanium and it is available in two sizes of 76 mm and 69mm variations of this concept have marketed by different implant manufactures. Stryker Corporation USA has modified the calcaneal plate design into two separate plates

The standard laterally placed plate is thicker, and has been modified somewhat to have two arms perpendicular to the main plate, this is to allow tuberosity and anterior end stabilization. The oblique arm allows the placement screw in sustentacular region.

LOCKING PLATE AND SCREWS

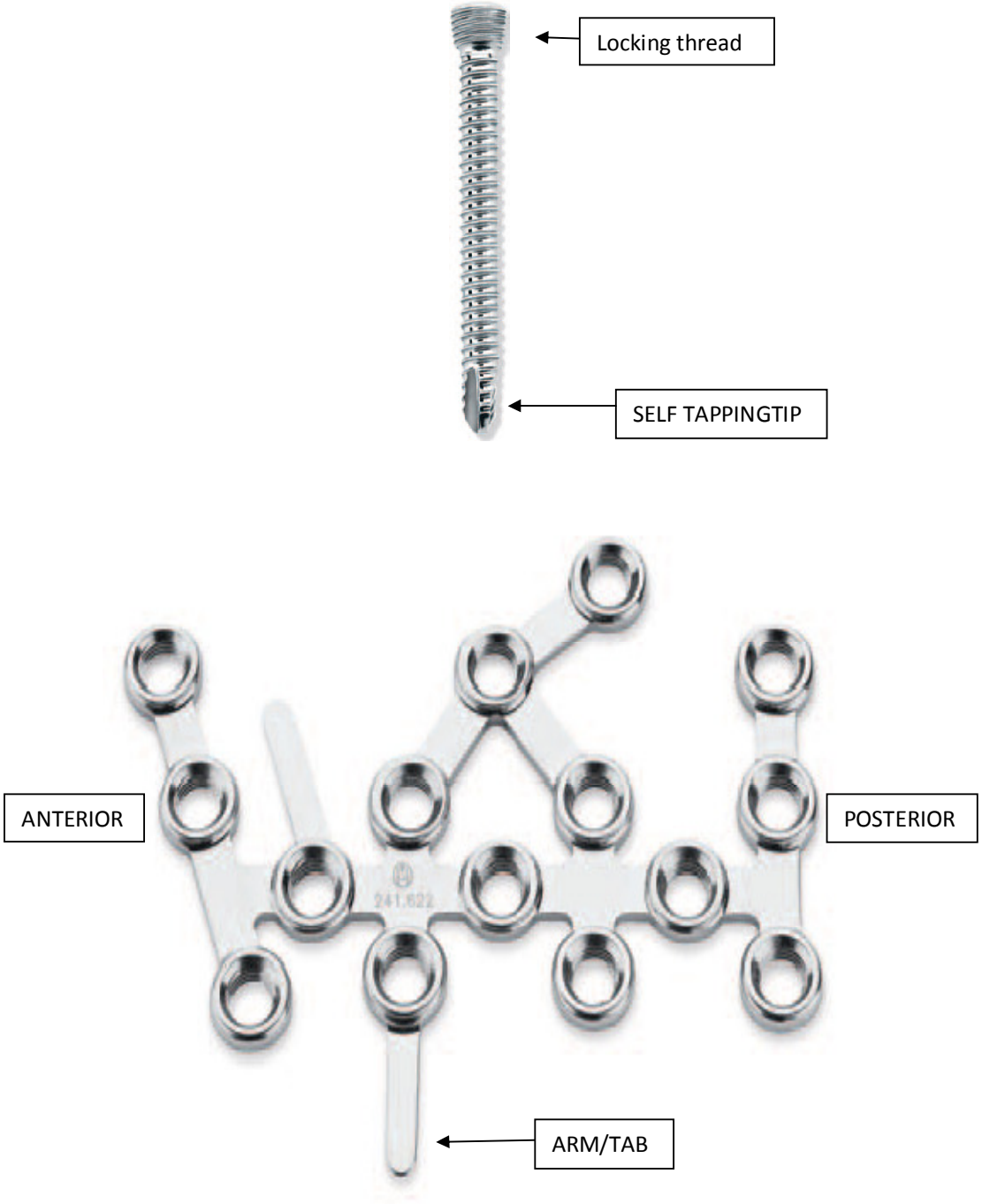
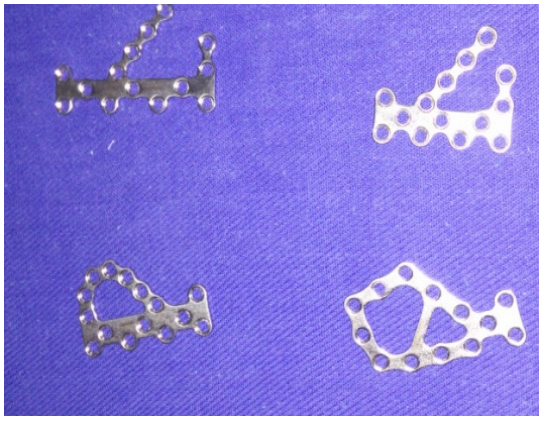


Fig. 19, 20 Locking Plate and Screw

Fig. 21 Locking Plate superimposed over calcaneum bone outline

The mesh plate design provides surgeons with an extremely low profile plates (1mm thick). Their advantage is that they can be easily contoured, and also they has many screw placement options .



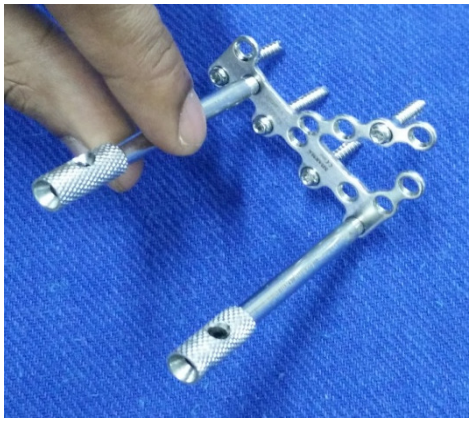


Fig 22 Various calcaneum locking plates

INCLUSION AND EXCLUSION CRITERIA

INCLUSION CRITERIA
➢ All closed intra articular, displaced calcaneal fracture
EXCLUSION CRITERIA
➢ Open fractures ➢ Diabetic neuropathy ➢ Significant coexisting diseases, with contradiction to any anaesthesia

Total number of cases	15
Bilateral	2

Sex	No's
Male	15
Female	Nil

Mode of injury	No's
Fall from height	13
RTA	2

Sander's Type in CT scan	No. of Cases
II III	6 9

ASSOCIATED INJURIES

Thoracolumbar fractures	1
Fracture tibia	1

ADDITIONAL PROCEDURES	
Tibia nailing	1

SURGICAL TECHNIQUE FOR OPEN REDUCTION AND INTERNAL FIXATION

Patient in lateral position, under spinal anaesthesia in 14 cases and General anaesthesia in one patient with spine injury, pneumatic tourniquet was applied after intra venous prophylatic antibiotics.

Through lateral extensile incision (Benirschke and Sangeorzan) .Sural Nerve explored and protected within retracted flap. Sub-periosteal dissection of anterior skin flap with K wire retraction. Peroneal tendon sheath dislocated over fibula.

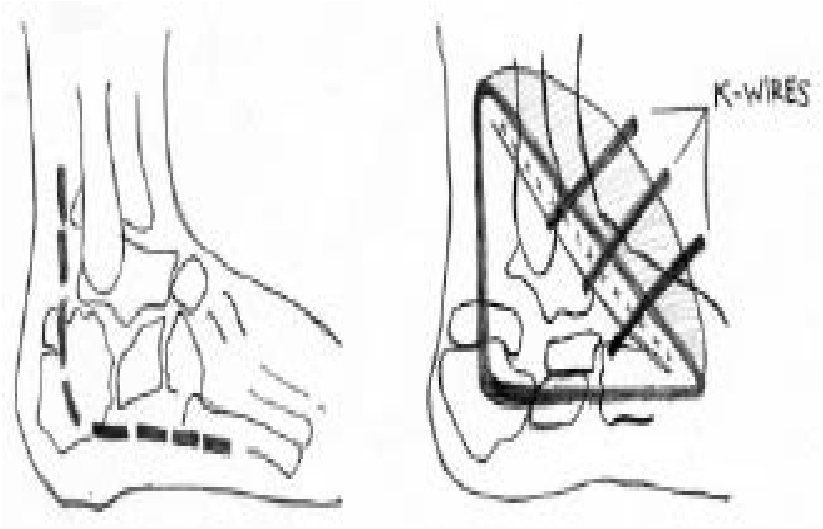
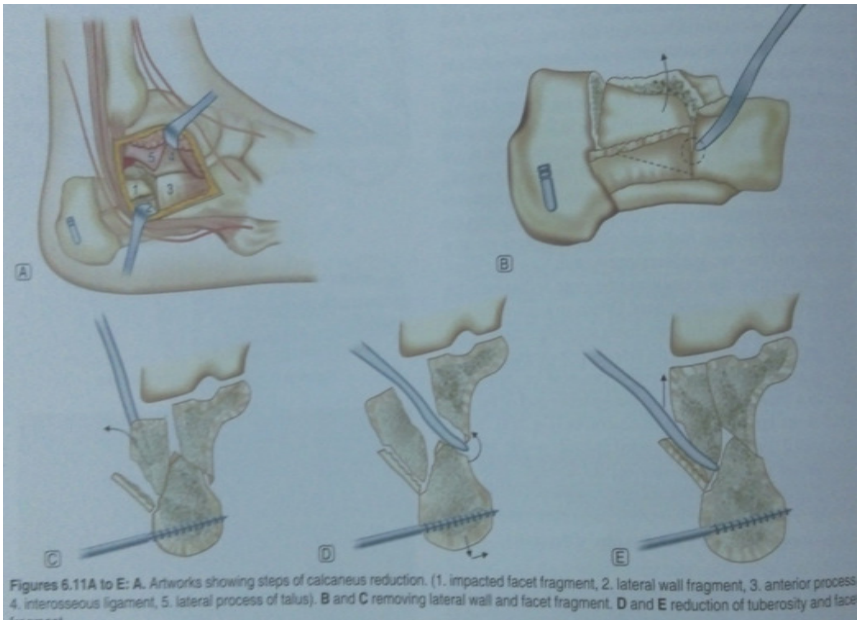


Fig. 23(a,b). Extensile lateral approach and flap retraction with K-wires

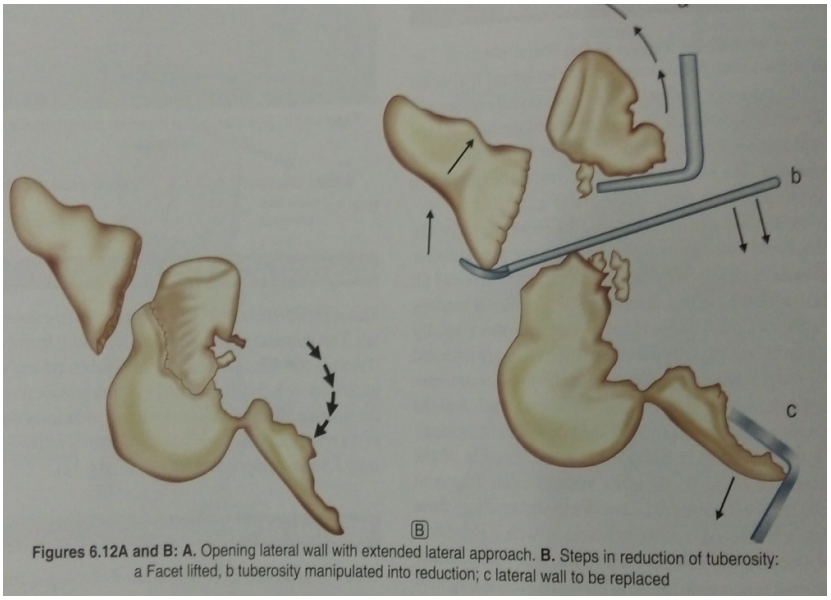
One K-wire is passed in fibula, talar neck and cuboid each (Fig.23b). As shown in above figure. The lateral wall of calcaneum is excised, the body and the tuberosity of calcaneum is mobilisd. Correction

of varus, loss of height and increased width is done. This arrangement is temporarily stabilized (tuberosity to medial fragment) with K wires. This is followed by reconstruction and fixation of intra articular fragment. This is again temporarily stabilized with a K wires. Then insertion of 2 parallel partially threaded small fragment cancellous screws is done. Reduction of anterior and middle facets and calcaneocuboid joint is done if necessary. Application of locking compression calcaneal plate, locking screws is used for plate fixation. Intra operative radiographic evaluation with image intensifier with lateral, axial and Antero posterior view. 4 -0 Prolene® "corner stitch" 2-0 Vicryl ®subcutaneous layer closure done with minimal sutures• Skin is closed with staples or Ethilon®. Sterile dressing followed by well padded short below knee slab is applied.

STEPS IN REDUCTION OF TUBEROSITY AND FACET



Figures 6.11A to E: A. Artworks showing steps of calcaneus reduction. (1. impacted facet fragment, 2. lateral wall fragment, 3. anterior process 4. interosseous ligament, 5. lateral process of talus). B and C removing lateral wall and facet fragment. D and E reduction of tuberosity and face



Figures 6.12A and B: A. Opening lateral wall with extended lateral approach. B. Steps in reduction of tuberosity: a Facet lifted, b tuberosity manipulated into reduction; c lateral wall to be replaced

Fig 24. Steps in reduction of Tuberosity and Facet

POST OPERATIVE MANAGEMENT

Limb elevation, intravenous antibiotics for five days. Smoking is avoided atleast sutures are removed. Closed suction drainage is kept for 24 — 48 hours. Short leg splint is removed at fifth postoperative day. If the flap shows uncomplicated healing and the wound is healthy, early active range of motion is begun at that time. At second Postoperative week, active range of motion of the ankle joint is started and gentle passive movement of subtalar joint done. Suture removal at 3 weeks. Weight bearing is allowed after 12 weeks, till that protection can be provided with removable posterior splint. The plate removal is necessary if the patient shows symptoms that too after one year.

Illustrated cases

CASE NO.1

56 years male, Mr.JR, a manual labourer presented with an history of RTA, sustained right calcaneal and both bone leg fracture in the same leg, there was swelling and pain in the heel and leg (Fig.25,26). There was no other spinal or pelvic injury or history of loss of consciousness. His CT scan revealed Sander's type3 pattern (Fig.27), the patient was operated on 13th day after trauma (Fig.29). Open reduction and internal fixation of calcaneum was done (Fig.30,31). Postoperatively patient developed mild infection of the surgical wound, which was settled in two weeks (Fig.28). According to AOFAS patient had a fair result with 68 score, for his tibia fracture closed nailing was done prior to calcaneal fixation. He returned to his work in four months (Fig 32).

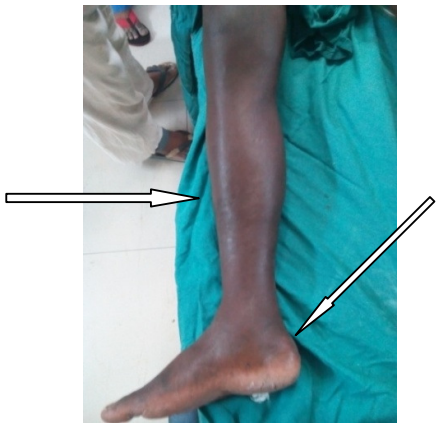


Fig. 25 Preoperative skin condition(upper arrow showing site of tibia #,lower arrow showing site of calcaneal #)

Fig 26.Preoperative radiographs showing intra articular fracture

Fig 27. CT scan Sanders type-3

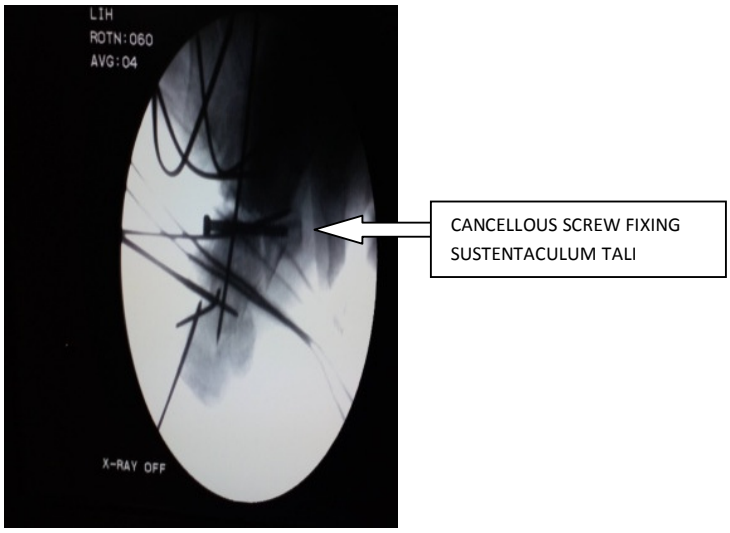


Fig 28 Post operative wound **Fig 29 axial view taken intraoperatively**

Fig 30,31 Axial and lateral post operative radiographs

Fig 32 Functional outcome

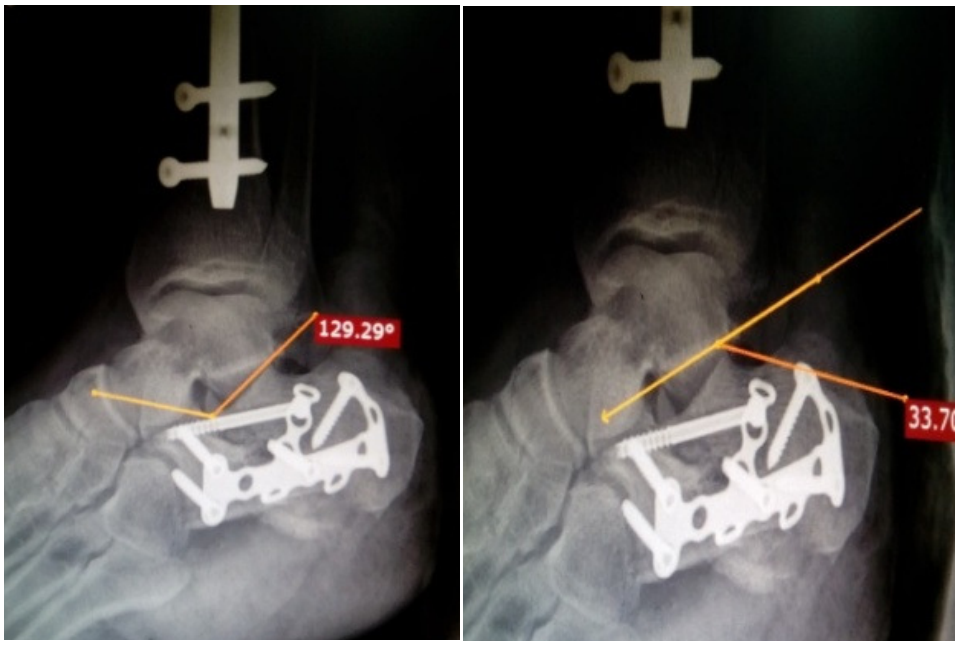


Fig 33, 34 Radiological Outcome

CASE NO.2

45 years male, Mr.VR, a mechanic presented with a history of fall from height. There was swelling and pain in the left heel. His CT scan showed Sander's type 3 calcaneal fracture (Fig.35). He was operated on 15th day (Fig.36, 37). He developed wound infection (Fig.39) which healed later by secondary intention. According to AOFAS this patient had a poor result with 48 score. After seven months implant was removed.

Fig 35 CT Scan Sander's type 3

Fig 36 Post operative radiograph shows fixation with moulding of the arm of the plate over the tuberosity

Fig 37 Radiological Axial, Anteroposterior, lateral views of calcaneum showing good reduction

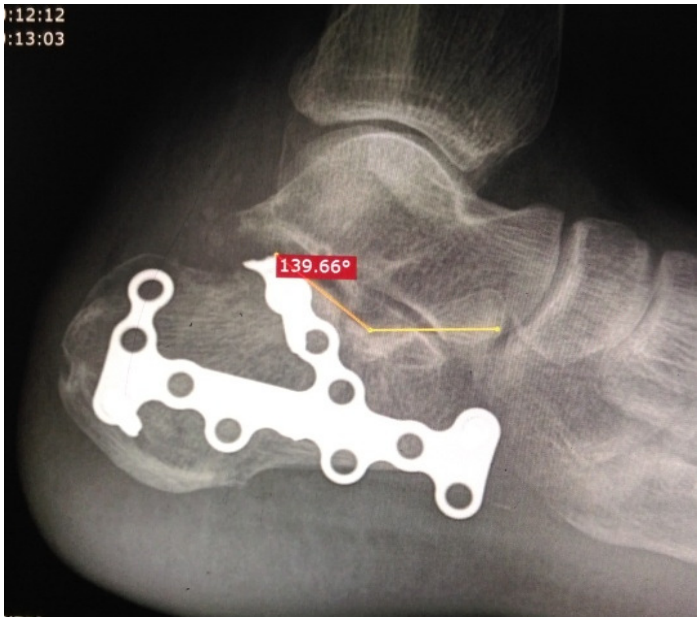


Fig 38 Radiological Outcome of case 2

Fig 39 Infection of the surgical wound

CASE NO.3

Mr.VP, 32 years old male, a farmer presented with swelling and pain in the heel after an motor vehicle accident, his Xray showed (Fig.41) calcaneal fracture and his CT scan showed (Fig.42) Sander's type 3. He had wound in the medial side of foot (Fig.40). He was operated on 7th day after trauma. An Open reduction and internal fixation of calcaneum (Fig.43, 44) was done, Post operatively his wound healed well. According to AOFAS he had a good result with 93 score.

Fig 40 Preoperative skin condition

Fig. 41 Preop x- ray

Fig. 42 CT Sander's type 3

Fig. 43 Intraoperative image showing gentle retraction of the entire flap in one layer

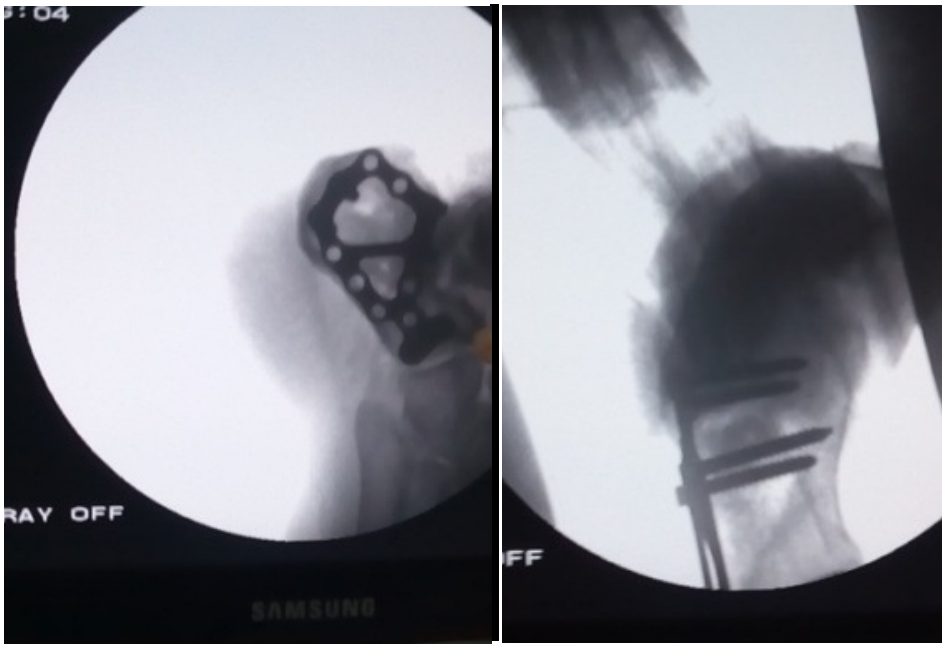


Fig. 44 Intraoperative C arm image(lateral /axial view)

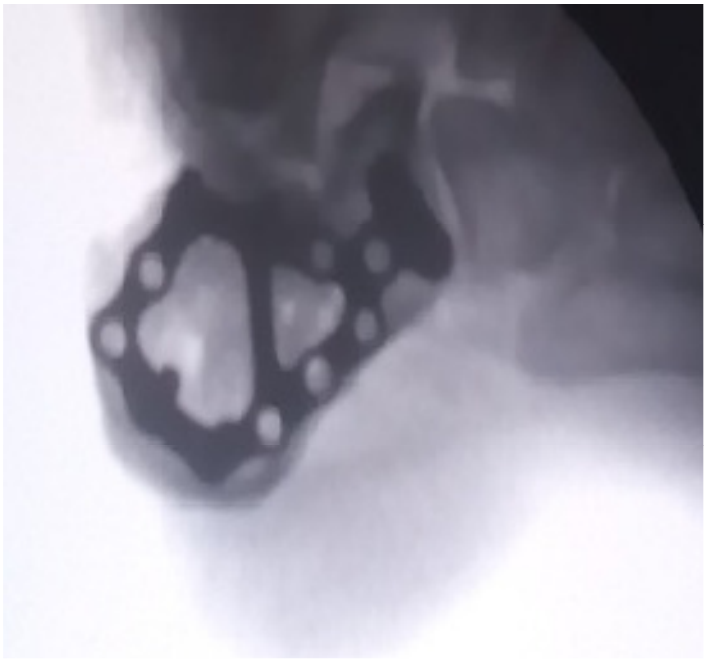


Fig. 45 Post operative radiograph showing good placement of the plate

Fig. 46 Functional outcome in case 3

CASE NO.4

Mr.D, 27 years old male, a labourer presented with after a fall from height and his radiograph (Fig.47) showed a fracture of calcaneum. His CT scan showed (Fig.48) Sander's type 2. He was operated on 8th day after trauma, (postoperative radiograph is seen in figure 49) Postoperative period was uneventful and the wound healed well (Fig.50). According to AOFAS he showed a good result with 81 score (Fig.51). The radiological reconstruction is seen in figure 52.

Fig. 47 Preoperative radiographs

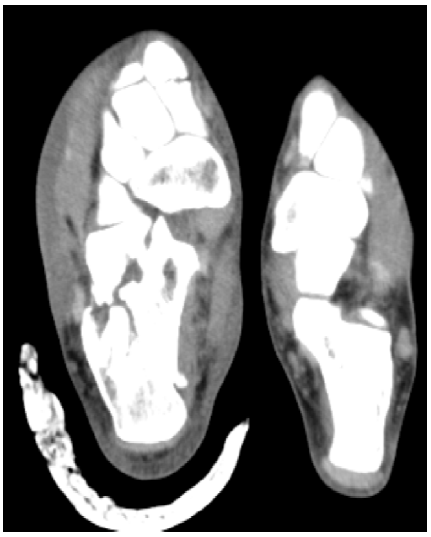


Fig. 48 CT scan Sander's type2

Fig. 49 Post operative radiograph

Fig. 50 Post operative wound showing good healing

Fig. 51 Functional outcome of case 4

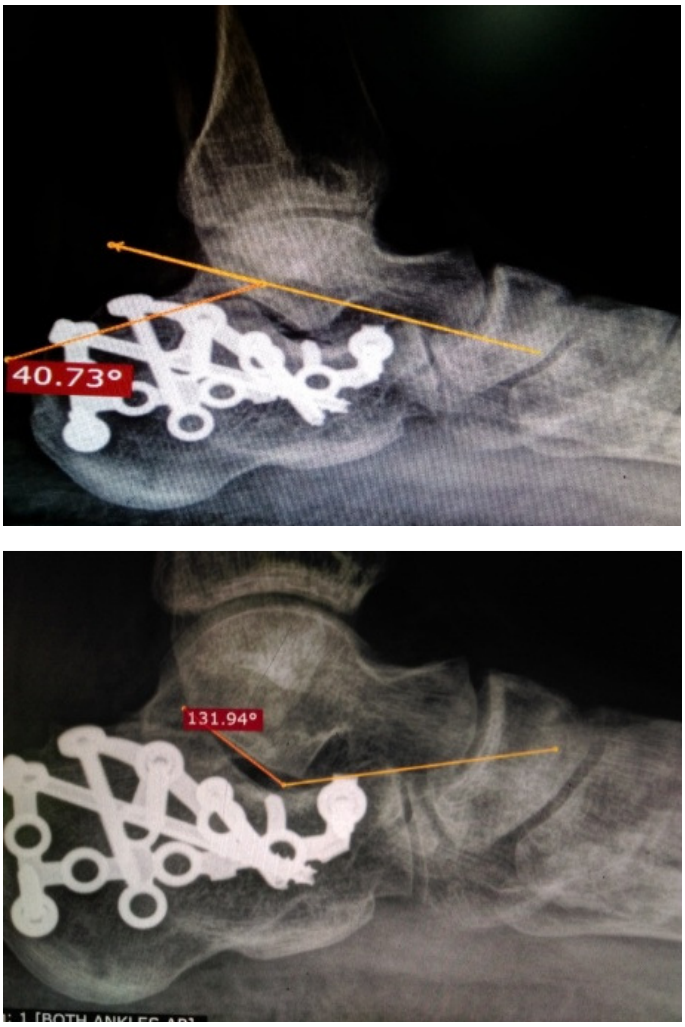


Fig. 52 Radiological Result of case 4 showing restoration of Bohler's and Gissane's angle

CASE NO.5

Mr.SM, 43 year male, a farmer presented after a fall from height, his radiograph revealed calcaneal fracture (Fig.53) and CT scan (Fig.54) showed Sander's type-2 fracture pattern. He was operated on 5th day after trauma, his intraoperative image and immediate postoperative wound are shown in figure(54, 55). In the postoperative period his wound healed well. According to AOFAS this patient showed good result with 97 score (Fig.59). The radiological angles reconstruction is shown in figure 60.

Fig.53Preoperative Xrays

Fig.54 CT image showing Sander's type 2

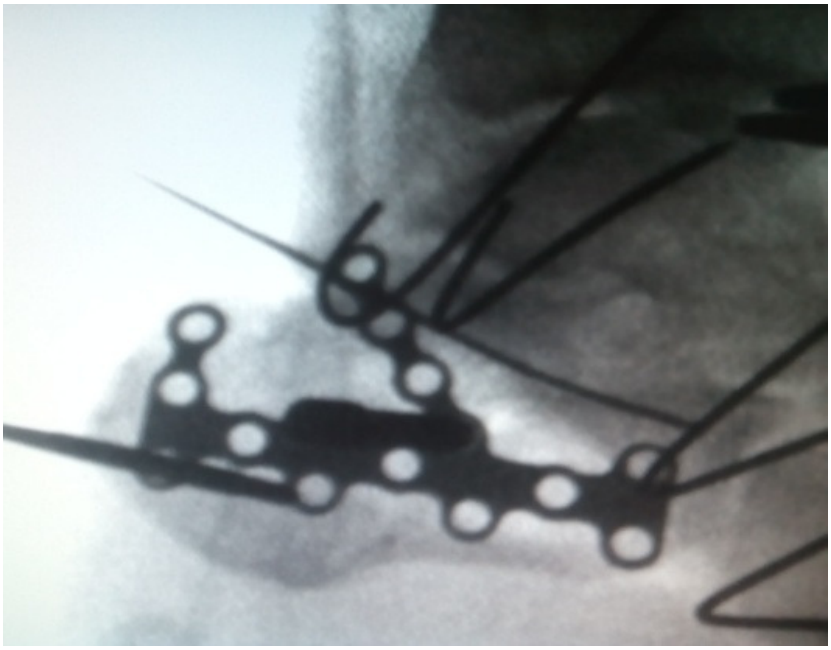


Fig. 55 Intraoperative C arm view

Fig. 56 Immediate Post operative wound

Fig. 57 Post operative radiograph lateral view

Fig. 58 Postoperative CT image. The axial section

Fig. 59 Clinical Outcome Pictures (Right side is the operated side)

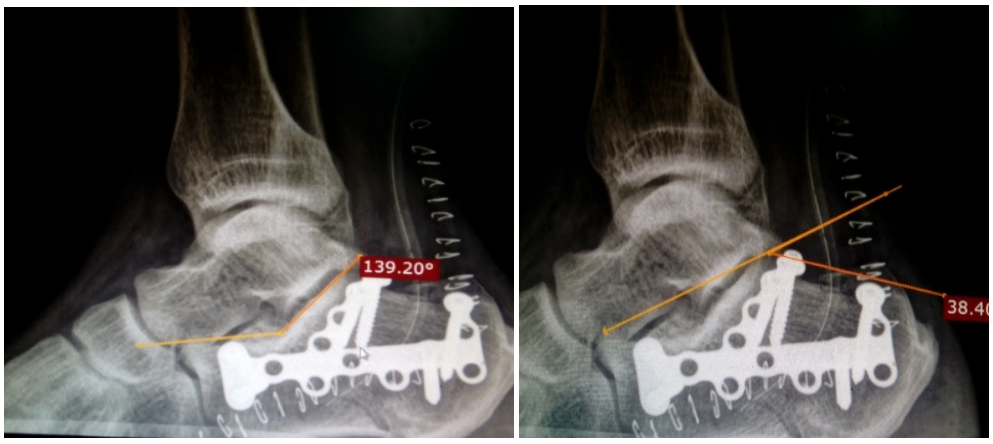


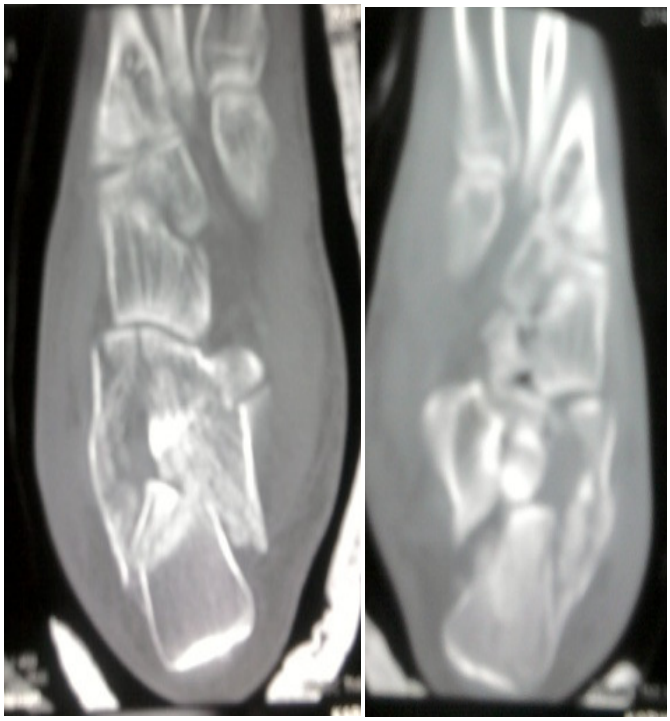
Fig. 60 Postop radiolography showing the reconstruction of Gissane's and Bholer's angle

CASE NO.6

Mr K, 43 year male, a painter, had a fall from height of around 20 feet, and sustained bilateral calcaneal fracture shown in figure 62, 63. His CT scan(Fig.64a,b) showed Sanders type 3 fracture pattern in both sides. He was operated on 5th day for left side, 6th day for right side after trauma. His postoperative period was uneventful. The postoperative radiograph is seen in figure 65(a,b). He was kept on non weight bearing for 12 weeks. He returned to his work by 16 weeks. According to AOFAS he showed good results with 78 and 81 scores for left and right side respectively.

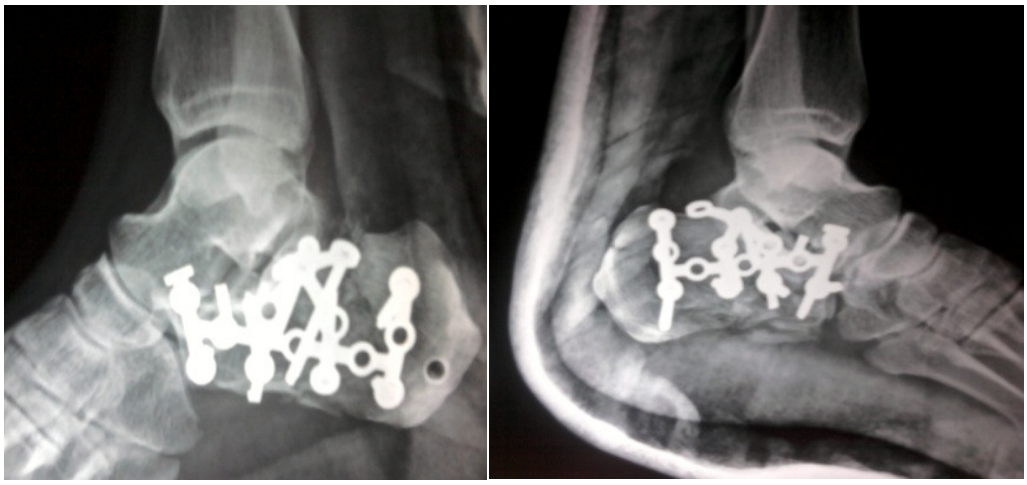
Fig. 61, Preoperative clinical picture

Fig.62,63 radiological images of right and left calcaneum



a.Left side **b.Right side**

Fig. 64(a,b) CT scan Sander's type 3



a.Left side **b.Right side**

Fig. 65a, b Post op radiological pictures

Fig. 66a, Postoperative follow up pictures showing inversion

Fig. 66 b. Postoperative follow up pictures showing plantar flextion

RESULTS

Bony union occurred in all patients. Two patients had superficial wound infection which settled with appropriate antibiotics. Two patients had superficial wound dehiscence among that one healed by secondary intention, other patient went for implant removal after radiological evidence of fracture union.

None of the patients had compartment syndrome, heel pad problems, peroneal tendinitis and a reflex sympathetic dystrophy

The results of this study were analyzed using the AOFAS score (American Orthopaedic Foot & Ankle Hindfoot Score). This scoring system is extensively used and it permits for comparison of results among several studies. The patients were evaluated using the AOFAS score as follows:

ANKLE - HINDFOOT SCALE (100 POINTS TOTAL)

PAIN (40 Points)	
*None	40
*Mild, Occasional	30
*Moderate, daily	20
* Severe, almost always present -	0

Function (50 Points) support requirement Activity limitations,	
No limitations, no support	10
No limitation of daily activities, limitation of recreational activities, no support	7
Limited daily and recreational activities, cane -	4
Severe limitation of daily and recreational activities, walker, crutches, wheelechair, brace	– 0
Maximum walking distance, blocks	
Greater than 6 blocks	5
4—6 blocks	4
1—3 blocks	2
Less than l block	0

Walking surfaces	
No difficulty on any surface	5
Some difficulty on uneven terrain, stairs inclines, ladders	3
Severe difficulty on uneven terrain, stairs, inclines, ladders	0

Gait abnormality	
None or slight	8
Obvious	4
Marked	0

Sagittal motion (flexion plus extension)	
Normal or mild restriction **(30^o** or more)	8
Moderate restriction (15° - **29^o)**	4
Severe restriction (less than 15°)	0

Hind foot motion (inversion plus eversion)	
Normal or mild restriction (75% - 100% normal)	6
Moderate restriction (25% - **74%** normal)	3
Marked restriction (less than 25% normal)	0

Ankle — hindfoot stability (anteroposterior, varus — valgus)	
Stable -	8
Definitely unstable – 0	0

Alignment (10 points)	
Good, plantigrade foot, ankle-hindfoot well aligned -	15
Fair, plantigrade foot, some degree of ankle-hindfoot malalignment observed no symptoms	8
* Poor, non-plantigrade foot, severe malalignment, symptoms	0

* Good : >75

* Fair 50—74

* Poor <50

In our study the results were as follows:

Good	10
Fair	4
Poor	1

ANKLE AND HINDFOOT SCORE - AOFAS chart

S: no	NAME	PAIN (40)	FUNCTION(50)							ALIGN MENT (10)	TOTAL (100)
			L	WD	WS	G	SM	HFM	AHS		
1	SM	40	7	5	5	8	8	6	8	10	97
2	JR	20	4	4	3	8	8	3	8	10	68
3	RK	20	4	4	3	8	4	3	8	10	64
4	SN	30	7	4	5	8	8	3	8	10	83
5	VP	40	7	4	5	8	8	3	8	10	93
6	PR	30	4	4	5	8	8	3	8	10	80
7	IA	30	4	4	3	8	8	3	8	10	78
8	DN	30	7	4	3	8	8	3	8	10	81
9	AN	30	7	2	3	4	4	3	8	10	71
10	SR (R)	30	7	4	3	4	4	3	8	10	73
11	SR (L)	30	4	4	3	8	8	3	8	10	78
12	VR	0	7	2	3	4	8	6	8	10	48
13	SB	30	7	5	5	8	8	3	8	10	84
14	KK(L)	30	4	4	3	8	8	3	8	10	78
15	KK(R)	30	7	4	3	8	8	3	8	10	81
16	MJ	30	7	5	3	8	8	3	8	10	82
17	VA	30	4	4	3	8	8	3	8	10	78

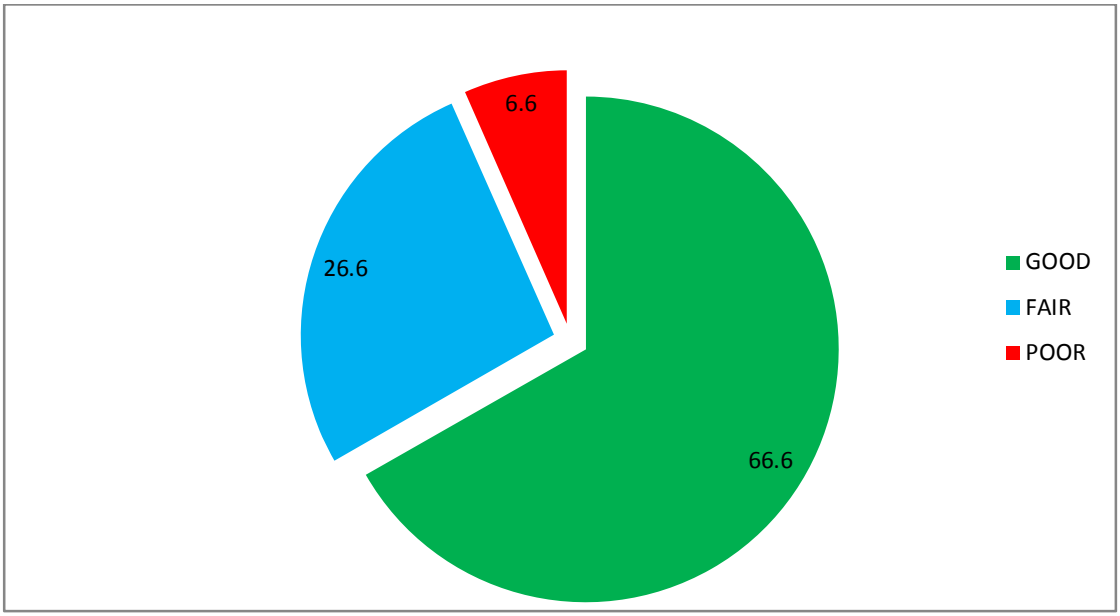
L – Limitation ; WD – Walking Distance ; WS – Walking Surface

G – Gait ; SM – Sagittal motion ; HFM – HindFoot Motion

AHS – Ankle HindFoot Stability ; L-Left; R-Right

RESULTS BY

ANKLE AND HINDFOOT SCORE



COMPLICATIONS

In our study we encountered the following complications

Superficial wound infection - 2

Minor wound dehiscence - 2

Inadequate reduction - 2 (Arthritis in one)

Sural nerve hypoaesthesia – 2

The results of the surgical procedure analyzed radiographically and clinically at 4 months post operatively and periodically afterwards. In the initial cases which we operated, we had complications like superficial wound infection, wound dehiscence and inadequate anatomical reduction. These complications developed due to delay in operative treatment. Later cases had no skin complications.

The poor results were due to prolonged operative time in reducing the fractures which were taken up late for surgery. However, bony Union was achieved in all cases.

DISCUSSION

17 calcaneum in 15 patients were operated and followed up. Their were assessed using AOFAS at 6th and 12th week. Various outcomes from various studies done globally are presented in the table below.

	Authors	**Year**	**Good results in% of cases**
1	McReynolds	1982	82.5% of cases
2	Palmer	1948	90%
3	Stephenson	1993	77/22 patients
4	Benirschke	1993	in 49/65
5	Thordarson & Krieger	1996	AOFAS 75%.
6	our study	2013-2015	66.6% good ,26.6% fair, 6.6%poor

In patients with displaced Sanders type II or III calcaneal fractures to reduce both the calcaneocuboid and subtalar articulations, to start early rehabilitation, Open reduction and internal fixation with calcaneal Locking plate through an extended lateral approach is preferred

Due to the risk of early complications, a clear idea about indications and contraindications and the timing of surgery are important. Pre and postoperative CT scans are essential. Fractures presenting with compartment syndrome are indicated for urgent fasciotomy and plating should be delayed.

In patients with open calcaneal fractures and multiple trauma, a temporary stabilization with an external fixator medially can be done first, and then converted to a second stage open reduction and internal fixation procedure.

Sustentaculum tali screw fixation has provide the advantages of high stability, less postoperative pain, strong fixed strength, rapid functional recovery in treating Sanders type II and III calcaneal fractures[21].

The poor results in our patient were in the patient taken later 2nd week.

The calcaneus locking plates has come closer to address nearly all the problem of calcaneal fracture fixation. It has specific proven merits with lower profile, better hold in bone, and versatile screw placement, reducing the need for graft or bone substitutes and allowing for earlier weight bearing. This documented by the study of Rak et al[36] , who compared results of 42 non locking plates with 34 locking plates and found lesser complications and better results with the former.

A study by Hyer et al-2010[37], further showed that there was no significant loss of calcaneal height, stability or joint reduction after early weight bearing of calcaneal fractures fixed with locked plates. These outcomes were found to be due to the inherent stability of the locking plate construct.

Variations of the plate construct have also directed to the evolution of the so called "wave plate" by Tornier Medical®, Saint Ismier Cedex France. This plate's design allows it to get accommodated in a less invasive incision. This plate is the form of a wave and can be inserted percutaneously by a less invasive incision. The anatomic contour of the plate was created after detailed CT study of over 30 different calcaneal anatomical patterns; the plate has a non locking apex hole, which provides optimal lag reduction of the sustentaculum tali. Each extra hole allows a non locking or locking screw option. This plate has specific reduction instrumentation for tuberosity manipulation during the fracture reduction.

Thus at present the locking plates for comminuted calcaneus fractures seems to be the best choice[38]. But surgical expertise and cost of the plate are two main limiting factors. They should be considered and analyzed along with the benefits of the procedure because implant affordability and availability of technical expertise is often a problem or

challenge in developing countries. It is very important to consider that calcaneal fracture surgery using complex implants has a steep learning curve and requires more professional expertise.

FUTURE DIRECTIONS AND INNOVATIONS

In future the focus should be on developing refined percutaneous, minimally invasive techniques. New plates like polyaxial locking plates can be useful. Multidirectional screw locking with non parallel is possible. The plate itself does not possess a thread, but a lip, and the screw with extra thread in the head cuts and thread into the plate at an angle determined by the surgeon. Due to increasing thread diameter, the screw locks in this position. The plate can be moulded as the plate and screw is made of titanium of different hardness grade. Since the plate is softer than screws and a special screw driver is needed to tighten the screws and ensure that they cut a thread into the lip of the plate.

BIOABSORBABLE IMPLANTS AND SCREWS

Evolution of bioabsorbable implant has made many professionals to apply them in selected calcaneal fractures. The problems of the metallic implants are high infection rate, irritability of plate and later need for implant removal make the option of bioabsorbable implants theoretically attractive, Zang and colleagues[39] have used bioscrews and prospectively compared them with plates in 97 randomized patients over a two year period.

They found acceptable results at a followup of an average 23 months. Bioabsorbable implants may not be strong enough to withstand the stress of these displaced calcaneal fractures and their indications in complex calcaneal fractures are hence limited now. Min and colleagues[40] have used bioabsorbable pins for calcaneal fracture; however they need long follow up and assessment in calcaneal fractures.

CONCLUSION

In displaced intra-articular fractures of calcaneum osteosynthesis by open reduction and internal fixation with locking plate using extensile lateral approach after adequate preoperative planning gave early functional recovery with acceptable results. Careful consideration of the surgical technique is a must.

The above method not only restored anatomical height, width of calcaneum, but also its Bohler's and Gissiane's angles. This allows early mobilization.

The timing of the surgery is a vital determinant for the treatment outcome and determined by subsidence of edema and appearance of wrinkle sign. Those cases which were taken up for fixation early within 10 days had good results than those which were operated later. These patients had superficial wound infections and minor wound dehiscence.

If for other reasons operation is done after three weeks, it causes not only soft tissue healing problems and high infection rate but also intraoperative difficulty in fracture reduction, as the fracture has started consolidation. Hence it is better to delay surgery till soft tissue heals and during this presurgical period patients should be managed by splintingwith proper padding, limb elevation.

To conclude intra articular calcaneal fractures are complex fractures which are difficult to stabilize and manage. The reason behind the improved results with open reduction and internal fixation in our series may be due to less traumatic techniques and stronger but malleable implants. Also locking plates for calcaneum decrease the need for bone graft, allow early weight bearing and it provides rigidity especially in osteoporotic cancellous bone. High cost and steep learning curve are the present limitations.

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PROFORMA

OUTCOME ANALYSIS FOR CLOSED INTRAARTICULAR DISPLACED CALCANEAL FRACTURES WITH LOCKING PLATE

Name : Patient ID :

Age :

Sex :

Mode of injury :

H/O loss of consciousness :

H/O chest pain :

H/O abdominal pain :

H/O back pain :

H/O weakness:

H/O loss of senation :

H/O bowel, bladder disturbances:

Past H/O : h/o CAD , CVA , HTN,DM

Personal H/O : h/o smoking , alcohol

General examination :

Vitals: PR,BP

Systemic examination :

- CVS
- RS
- ABDOMEN

LOCAL EXAMINATION OF ANKLE/HINDFOOT

LOCAL EXAMINATION OF SPINE/PELVIS/OTHER LIMBS

INVESTIGATIONS :

CBC

BT,CT

RBS

RFT

CXR

ECG

Xrays

Ankle AP/Lateral/

Calcaneum-Axial view

Pelvis with both hip-AP

Dorsolumbar spine-AP/Lat

CT calcaneum

PROCEDURE DETAILS

POSTOPERATIVE WOUND STATUS:

DATE OF DISCHARGE:

POST OPERATIVE FOLLOWUP

1st visit- 14TH Postoperative day

Suture removal

2nd visit-6th week

Xray-ankle AP/Lateral/Calcaneum axial view

Physiotheraphy

3rd visit-12th week

Physiotheraphy

4th visit-16th week

AOFAS SCORE

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MASTER CHART

Pt NO.	Name	Age	SEX	DM/ HT	Mode of injury	Sander's type	Presenting day	Operated day	Result at six week - wound healing	Overall result	AOFAS SCORE	Minor Complications settled	Major Complications needing removal of plate
1	SM	43	M	-	Fall from ht	2	1	5	good	good	97		
2	JR	56	M	-	RTA	3	1	13	Fair	Fair	68	SWI	
3	RK	21	M	-	Fall from ht	3	6	16	Fair	Fair	64	IR	
4	SN	34	M	-	Fall from ht	2	1	10	good	Good	83		
5	VP	32	M	-	RTA	3	1	7	good	Good	93		
6	PR	27	M	-	Fall from ht	3	1	9	good	Good	80		
7	IA	29	M	-	Fall into well	2	1	12	good	Good	78		
8	DN	27	M	-	Fall from ht	2	1	8	Good	good	81		
9	AN	44	M	-	Fall from ht	3	1	16	fair	Fair	71	SWI	
10	SR	25	M	-	Fall from ht	3	1	9(B/L)	fair	Fair	R-73/L-78	IR®	
11	VR	45	M	-	Fall from ht	3	1	15	poor	poor	48	DWI	Infection/ S.N.hypoasthesia
12	SB	32	M	-	Fall from ht	2	1	12	good	Good	84		
13	KK	43	M	-	Fall from ht	3	1	5(L)/6(R)	good	Good	L-78/R-81		
14	MJ	24	M	-	Fall from ht	2	1	11	good	Good	82		
15	VA	60	M	-	Fall from ht	3	1	8	good	good	78		

KEY TO MASTER CHART

SWI - Superficial wound infection

DWI - Deep wound infection

IR - Inadequate reduction

SN - Sural nerve hypoaesthesia